SUPER EXPANDED COLLECTOR'S EDITION

Astronomy®

HDG 08070

August 1998 • $4.95
U.K. £2.40
Can. $6.25

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25
YEARS

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LX50

Advanced technology at the most affordable prices *ever.*

■ **Battery-Powered, Completely Cordless Operation!** Meade LX50 models operate for more than 50 hours from six AA-size batteries inserted through the telescope's control panel. Or use the standard-equipment 25 ft. cord to power the telescope directly from any auto cigarette lighter plug.

■ **Standard-Equipment Declination Motor and Hand Controller:** Plug the hand controller into the LX50 control panel and you're ready for full dual-axis drive capability at any of 4 photo-guide or microslew speeds: 2x, 8x, 16x, or 32x, plus quartz-controlled sidereal-rate tracking in R.A. Switch speeds instantly using the speed-control button on the hand controller. Dual-axis drive rate is indicated by a red LED.

■ **Multi-Function Control Panel:** Includes connectors for CCD autoguiders; for the standard-equipment Declination motor; and for the optional Magellan II Computer-Corrector *(below).* A North-South switch permits telescope operation anywhere in the world.

■ **Super Multi-Coated Optics:** The exact same EMC super multi-coated optical tube assemblies included with Meade LX200 models.

■ **Massive LX200-type Fork Mounts:** Meade LX50 mounts are manufactured of the same virgin aluminum castings as Meade LX200 Schmidt-Cassegrains. Massive, rigid mountings that include the Meade LX worm-gear drive system with low periodic error for advanced photographic or CCD imaging applications. *No competing mid-priced equatorial mountings even come close.*

SPECIFICATIONS: 7", 8", and 10" LX50's—Each complete telescope includes 8" or 10" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty LX200-type fork mount; 5.75" LX worm gear system in R.A.; multi-function control panel; DC servo Declination motor; manual and electric slow-motion controls on both axes; setting circles on both axes; keypad hand controller; 4-speed drive controls on both axes; battery compartment accepting six (user-supplied) AA-size batteries; 25 ft. power cord for telescope operation from 12v. auto cigarette lighter plug; 6 x 30mm (7" and 8" models) or 8 x 50mm (10") viewfinder; 1.25" diagonal prism; MA25mm multi-coated eyepiece (1.25"); standard equatorial wedge with elevation scale, bubble level, and azimuth control; complete operating instructions.

8" LX50 Schmidt-Cassegrain	**$1395.**
10" LX50 Schmidt-Cassegrain	**1695.**
7" LX50 Maksutov-Cassegrain	**1795.**
Variable-Height Field Tripod	**295.**
7" Maksutov-Cassegrain Tube Ass'y	**1295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 7"—$125; 7" Tube Assembly—$65.

Meade Magellan™ II Computer-Corrector for LX50 Telescopes: Plug the Magellan II into the control panel of your LX50 and enjoy an incredible range of advanced capabilities. ■ Fast manual slewing to any object, either from input RA and Dec or from the 12,218-object database. ■ High-resolution 4096-pulse encoders (5.3 arc-minute precision), concealed in special LX50 encoder compartments. ■ Large 32-character, red-backlighted display. ■ Quick 2-star alignment. ■ Four-speed (2x, 8x, 16x, 32x sidereal) dual-axis drive corrector/microslewing system.

MEADE
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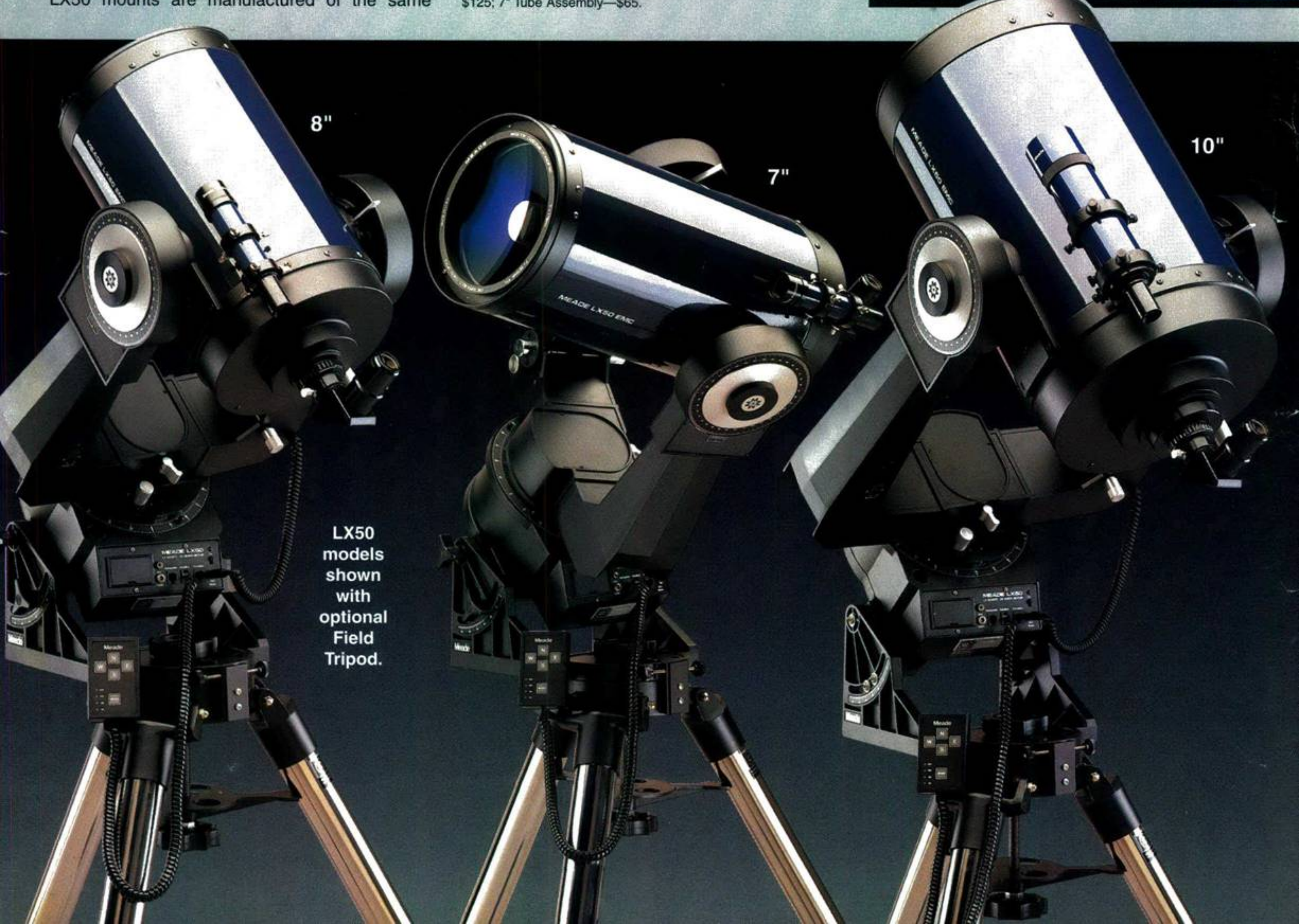
only $495!

#2024: Magellan II for LX50's—Includes Magellan II hand controller *(right)*; encoders for both axes; all required mounting hardware. Installs to any LX50 in minutes. **$495.** + $15 packing and shipping in the 48 states.



LX50 models shown with optional Field Tripod.

The largest-selling serious telescopes in the world.

LX200

In virtually every country in the world where serious telescopes are sold, more Meade LX200's are sold than all competing models *combined*. Consider these *standard-equipment* specifications:

- **Superb Optics:** LX200 diffraction-limited imaging capabilities are a legend in the industry; we regularly receive reports stating that optical performance approaches that of a fine *ED* apochromatic lens.

- **Automatic GO TO Capability:** Meade LX200's are *the only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec., or to any of 64,359 objects in the onboard database, *to a precision of one arc-minute or better.*

8" LX200 Schmidt-Cassegrain	**$2795.**
10" LX200 Schmidt-Cassegrain	**3195.**
12" LX200 Schmidt-Cassegrain	**4495.**
7" LX200 Maksutov-Cassegrain	**3295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125.

- **Meade LX200 High-Precision Pointing™** is so precise it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically — *a feat that no other telescope priced under $40,000 can accomplish.*

- **Permanently-Programmable Smart Drive™** routinely achieves 5 arc. sec. periodic error, an observatory standard.

- **9-Speed Dual-Axis Electronics:** Electronics that cover every possible contingency of telescope positioning—from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between.

- **Field Operation:** No other telescopes of such incredible capabilities transport so readily for field operation. The optional #1812 Electronic DC Adapter (a compact 4 oz. unit) allows for field powering directly from an automobile cigarette lighter plug.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's—Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC; 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

Write, call, or fax Meade Instruments for your free copy of the 100-page Meade General Catalog.

Prices shown are suggested U.S. mail-order retail prices.

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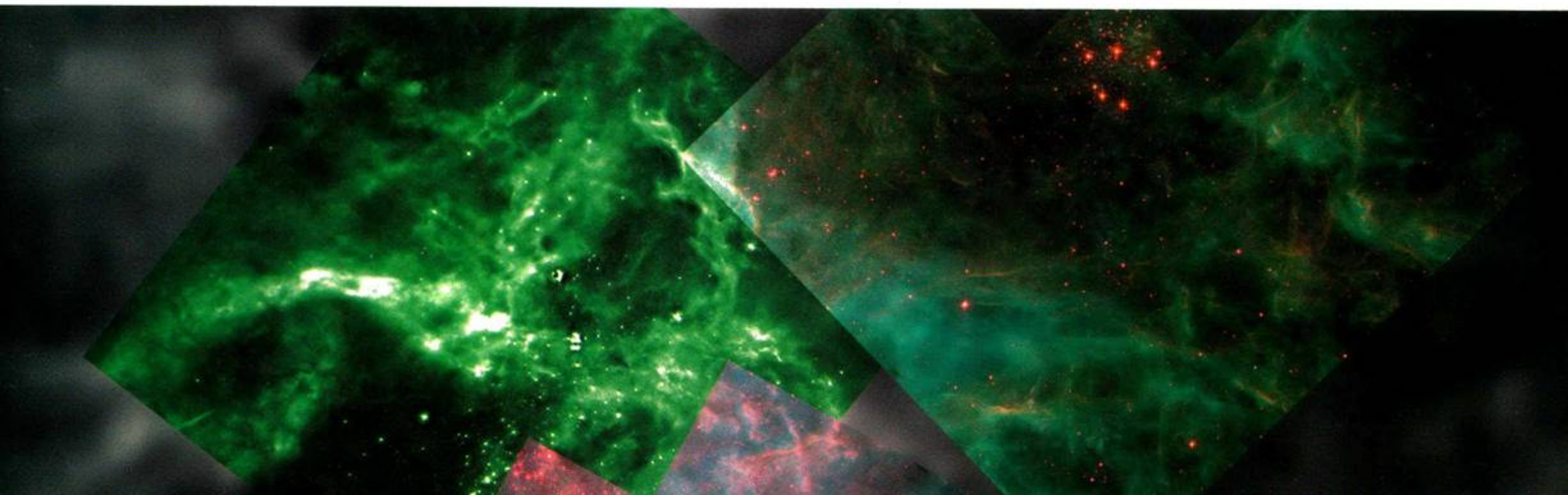

BEHIND THE SCENES

BY BONNIE BILYEU GORDON

Celebrating the Future

About a year ago, we began inviting astronomers and cosmologists to join us for lunch in Washington, D.C., to talk about the future. We figured this would turn into a nice feature story for our 25th anniversary issue. We chose the time and place because it coincided with the annual meeting of the American Astronomical Society. A few astronomers would be there and we figured we could entice some of them with the offer of rich foods. Some turned us down flat. (Rocky Kolb told us, "It's the height of ski season in Italy.") To our surprise, however, many of our target thinkers said yes and with great enthusiasm. As the acceptances rolled in, we grew more excited and more anxious. What questions would we ask? Could we count on lively disagreement? Would everyone show up?

As months passed, it became clear that our guest list would be changing. Such high-profile scientists would be called into essential AAS planning committees or they would fly off to Zurich for other meetings. We replaced the last minute drop-outs with great success.

CELEBRATES 25 YEARS

We also had more mundane problems. We didn't know much about the current Washington restaurant scene. But we have a staff member whose family lives in Washington, so we sent her to check it out. Her wonderful restaurant choices were all in walking distance of the Capitol Hilton, which she believed to be the venue of the meeting. But the meeting actually was planned for across town at the Washington Hilton, so we started over. We needed a reservation long in advance and we settled on Kinkead's though no one we knew had ever eaten there. When we arrived at our room in this Pennsylvania Avenue establishment four months later, we knew we had done the right thing. The heavy wood paneling, the etched glass room dividers, and crystal on the table lightened our moods. Our photographer, who would smoothly shoot our ongoing conversation while making formal portraits of participants at a tiny corner station, was already setting up when we arrived. Our recorders worked.

The end result was both stimulating and festive. The wine was waiting when we stepped through the door. We relaxed early, talked a lot, and everyone seemed to have a good time. When lunch was drawing to a close, John Mather of NASA said "I was skeptical that this would work, but I think it went very well." And Anne Kinney of the Space Telescope Science Institute caught me later at the AAS meeting and paid some of my staff members the best compliment. "It was great," she said. "And, you know, only a woman could have planned this." Well, I'm not sure, but I think a few men could foster fine conversation over lunch.

You can read the results for yourself, interpreted by *Astronomy* editor Rich Talcott on page 52. One point he left out: 17 years ago, one of our guests, Martin Harwit, published *Cosmic Discovery*. In it he wrote that only around 33 percent of the what's in the universe had been recognized. At our forum, he revised his position: "We may now have discovered 40 percent of the phenomena we'll ultimately recognize."

Thank you Martin. Thank you all.

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MEADE ETX

90mm Maksutov-Cassegrain

MEADE SUPER PLÖSSL
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Meade ETX Astro Telescope. Shown with optional #64 Photo Adapter.

SPECIFICATIONS: ETX Astro Telescope—Includes Maksutov-Cassegrain optical tube assembly (D = 90mm, F = 1250mm, f/13.8) with EMC super multi-coatings; internal flip-mirror system for either straight-through or 90° observing position; equatorial fork mount with slow-motion controls, locks, and setting circles in R.A. and Dec; table tripod with elevation scale on center tripod leg; motor drive system with internal battery compartment accepting three (user-supplied) AA-size batteries; 8 x 21mm achromatic erect-image viewfinder; Series 4000 Super Plössl 26mm eyepiece (1.25"); operating instructions. *Net weight 9 lbs.* **$595***
(+ $20 packing and shipping in the 48 states)
*Suggested U.S. mail-order retail price.

Now you can have diffraction-limited imaging and ultraportability ...at only *$595*, *complete!*

The revolutionary Meade ETX goes anywhere with you at a moment's notice and presents the finest optical images ever made available in an ultraportable telescope.

Optical System: Manufactured at the Meade Irvine, California facility, ETX diffraction-limited optics produce images so high in contrast, brightness, and resolution that the ETX consistently outperforms telescopes of much larger apertures. **Equatorial Fork Mount:** Precise polar alignment in *seconds,* just by extending the center tripod leg to read your latitude on the inscribed scale. **Cordless Motor Drive:** The internal drive system operates from 3 AA-size batteries that power the motor drive for more than 50 hours. A North-South switch permits operation anywhere in the world. **Flip-Mirror System:** Flip the internal optical flat mirror "up" for 90° observing; flip the mirror "down" for terrestrial observing with the optional #932 45° Erecting Prism or for photography with the optional #64 Photo Adapter. **Standard accessories** include a Series 4000 Super Plössl 26mm eyepiece and 8 x 21mm erect-image viewfinder.

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Meade Pictor 208XT
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Meade Pictor 416XT
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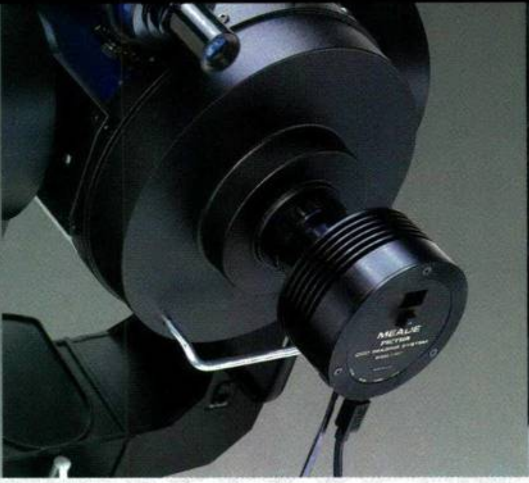
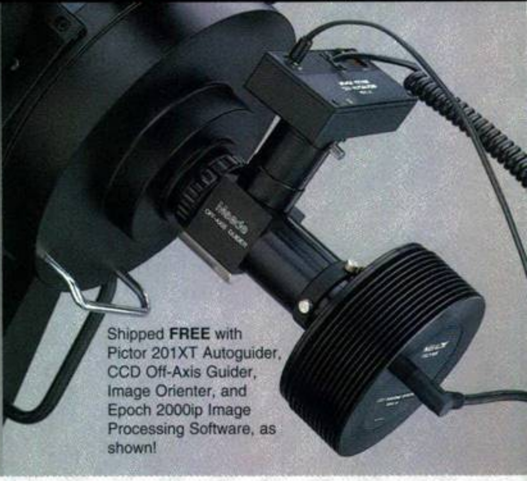
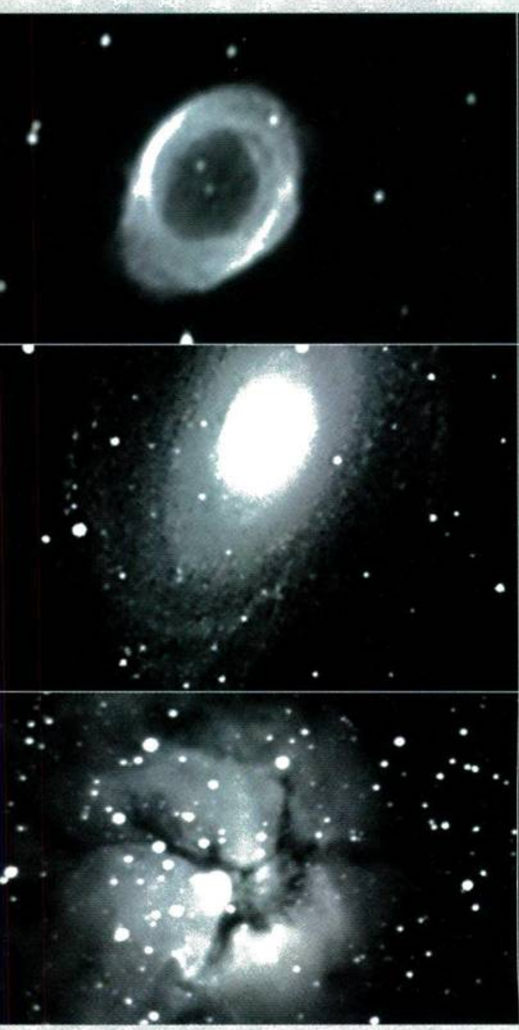
includes $800 Meade CCD Equipment System



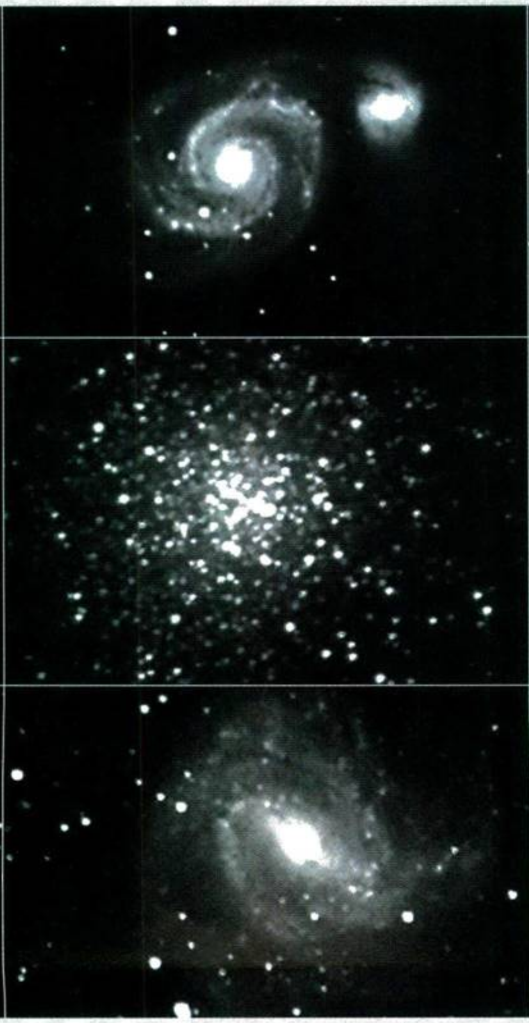


Shipped **FREE** with Pictor 201XT Autoguider, CCD Off-Axis Guider, Image Orienter, and Epoch 2000ip Image Processing Software, as shown!

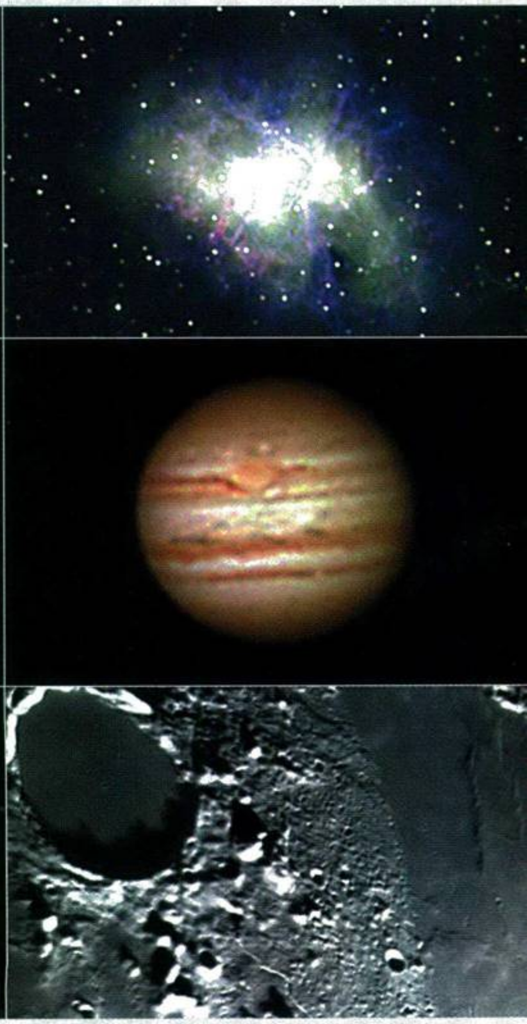
Revolutionary Meade Pictor CCD's are now the world's largest-selling autoguiders and imagers for the amateur astronomer. No other electronic imaging systems offer such an incredible range of capabilities at such amazing price levels. At only **$495** the **Pictor 208XT** produces on the PC display fine, high-resolution 8-bit images *in seconds* of the Moon and planets, or, in 2 or 3 minutes, of thousands of deep-space objects. At **$695** the **Pictor 216XT** enables advanced 16-bit imaging and is *by far* the finest autoguider/imager ever made available at under-$1000. At **$1695** the **Pictor 416XT** permits professional-level imaging capability for the amateur astronomer: an electronic camera capable of producing with amateur telescopes images of the Moon, planets, and deep-space that match or exceed the photographic images obtained with many observatory telescopes. All models are available for immediate shipment. ***For complete information on Meade CCD imaging systems write, call, or fax for your free copy of the 100-page Meade General Catalog.***



Pictor 208XT images *(top to bottom):* Ring Nebula (M57), 25" reflector, Jack Newton; Galaxy (M81) in Ursa Major, 12" LX200, Scott Roberts; Trifid Nebula (M20), 8" LX200, John Hoot.



Pictor 216XT images: Whirlpool Galaxy (M51), 12" LX200, John Hoot; Globular Cluster (M13), 25" reflector, Jack Newton; Galaxy (M83) in Hydra, 12" LX200, Scott Roberts.



Pictor 416XT images: Crab Nebula (M1), 25" reflector, Jack Newton; Jupiter, 10" LX200 with Stellar Products AO-2 seeing adapter, Dr. Donald Bruns; Moon (crater Plato), 16" f/6 reflector, Dr. Donald Parker.

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MEADE 102ED/APO EMC
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MEADE 203/SC EMC
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Model 102ACHR/500:
4" f/9 Achromatic
Refractor — **$995.**

Model 102APO/500:
4" f/9 *ED* Apochromatic
Refractor — **$1695.**

Model 114NT/500:
4.5" f/8 Newtonian
Reflector —
$595.

Model 127NT/500:
5" f/8 Newtonian
Reflector — **$695.**

Model 203SC/500:
8" f/10 Schmidt-
Cassegrain
— **$1295.**

MEADE 500-Series

Experience all of the high-resolution optical performance and mechanical precision of a MEADE reflector, refractor, or Schmidt-Cassegrain, at a moderate pricing level. Each complete 500-Series model includes the all-new MEADE LXD 500 equatorial mount with dual-axis worm gears, engraved setting circles, micrometric slow-motion controls in RA and Dec, rigid aluminum tripod, and a full complement of accessories. Choose from among five models the one that's right for your budget and observing requirements. *For complete details send for your free copy of Meade Bulletin 500.* Optional systems for Meade 500-Series telescopes include:

Shown with optional #1702 Dual-Axis Drive System

#1701 Single-Axis RA Drive System	**$145.**
#1702 Dual-Axis Drive System, with 4-speed hand controller	**195.**
#812 Polar Alignment Finder	**49.**

Prices shown are suggested U.S. national mail-order retail prices.
Packing and shipping: 4" models—$55; 4.5" and 5"—$45; 8"—$65.

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STARFINDER DOBSONIANS

No other competing Dobsonians include this listing of *standard-equipment* features:

Primary and Secondary Mirrors of Low-Expansion Pyrex® Glass: Unlike the plate glass optics of other Dobsonians that can become thermally unstable, all Meade Dobsonian optics are made of Grade-A fine-annealed Pyrex glass — the exact same professional-quality optics used on Meade Starfinder Equatorials.

Rigid, Durable, Beautiful Dobsonian Mountings, manufactured of cabinet-quality materials, provide extremely smooth motions of the telescope in both altitude and azimuth. Both telescope axes ride on zero-backlash Teflon/Nylon bearings, facilitating the quick location and easy tracking of celestial objects.

Full-Size 1.25" Rack-and-Pinion Focuser: For smooth, precise focusing of the image without wobble or backlash. Focus travel is 2.6"; accepts 1.25" eyepieces.

4-Vane Steel Secondary Mirror System: Permits locked-in support and precise centration and alignment of the secondary mirror.

Multi-Coated MA25mm Eyepiece (1.25"): The Meade Modified Achromatic 25mm eyepiece yields sharp, high-resolution imaging to the field edge.

5 x 24mm Viewfinder: Included with all Starfinder Dobsonian models for quick object-location in the main telescope. With crosshair eyepiece and 2-ring bracket.

Optical Tubes: Starfinder Dobsonians include the same strong, spiral-wound Sonotube™ optical tubes used on Starfinder Equatorials *(right)*, tubes with excellent insulating characteristics that reduce internal thermal currents to an absolute minimum.

Performance! *Meade Starfinder Dobsonians and Equatorials are the largest-selling Newtonian reflectors of their apertures in the world.* Every Starfinder model opens up the skies to an extremely wide range of serious visual observing; all 110 Messier objects, thousands of NGC objects — nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets in stunning high-resolution detail. Starfinder Dobsonians are telescopes for visual observing; motor-driven Starfinder Equatorials may be used, in addition, for lunar and planetary photography, and even for limited deep-space photography.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$39; 8"—$49; 10"—$69; 12.5"—$79; 16"—$45 packing, shipped truck freight collect.

Dobsonian Deluxe Accessory Package
only $49.95!

Outfit your Meade Dobsonian with all of the most popular accessories for advanced observing. At the time you order any Dobsonian model, specify the following Deluxe Accessory Package for your telescope, in place of the standard-equipment focuser, viewfinder, and eyepiece, ***for a total of only $49.95 additional:***

- **1 - Meade #77 2" Giant Rack-and-Pinion Focuser,** with machined aluminum eyepiece-holders for both 2" and 1.25" eyepieces; includes drawtube lock and 2.6" focuser travel. *(reg. $59.95)*
- **1 - Meade #637 6 x 30mm Achromatic Viewfinder,** with wide 7° field; 2-ring metal bracket. *(reg. $49.95)*
- **3 - Meade MA9mm, 12mm, and 25mm** multi-coated eyepieces, 1.25" barrel — eyepieces for the full range of lunar, planetary, and deep-space observing. *(reg. $37.95 each)*

Purchased separately, the Deluxe Accessory Package sells for $223.75!

Meade Magellan I
Telescope Computer System

Attach the optional Magellan I Telescope Computer System to your Starfinder Dobsonian and finding any of 12,218 celestial objects, or *any* object of known R.A. and Dec., is almost as easy as pointing the telescope! Magellan I's database includes the following objects:

7,840	NGC objects; the complete NGC catalog
4,093	IC objects from the Index Catalog
125	user-defined objects
110	Messier objects; the complete catalog
42	alignment stars for the Magellan system
8	major planets, from Mercury to Pluto
12,218	objects, total

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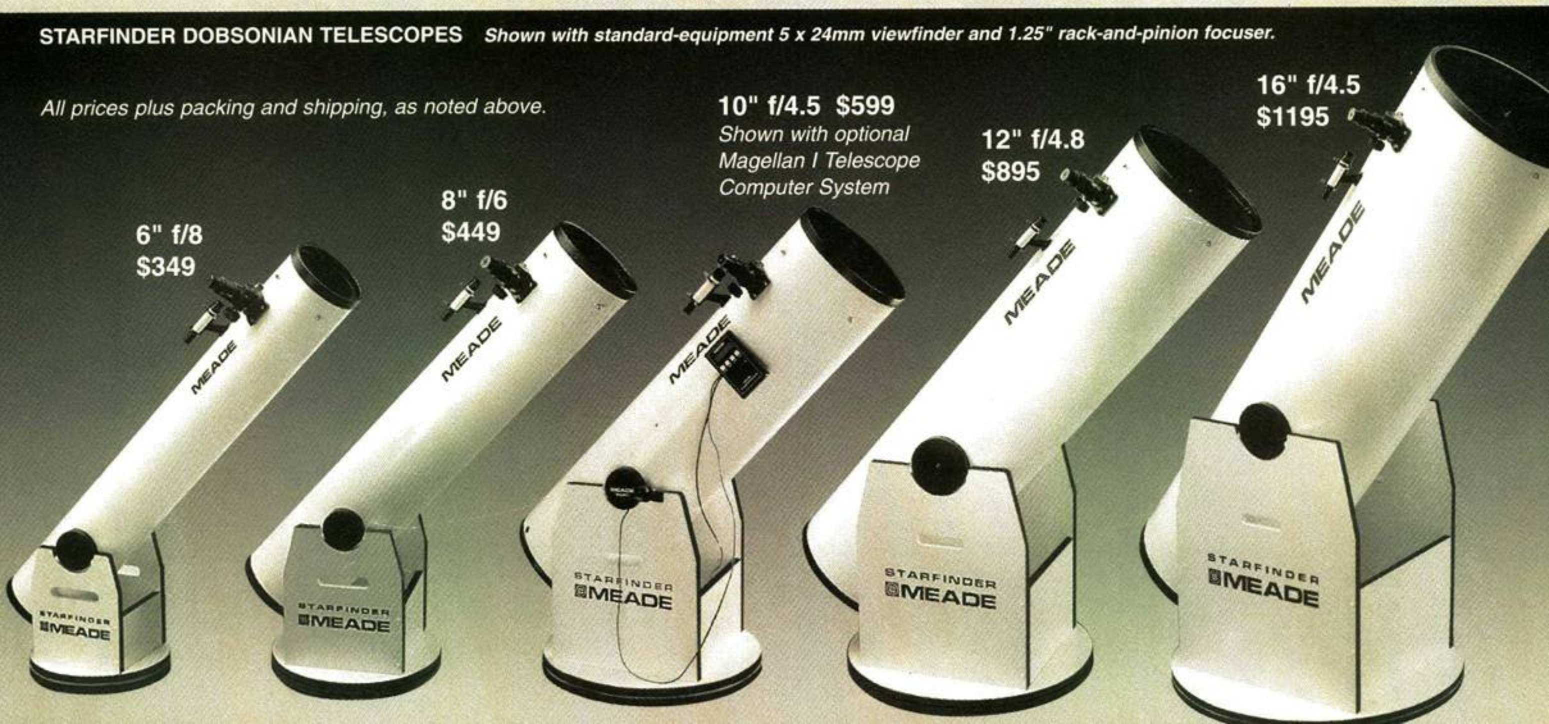
MAGELLAN I
TELESCOPE COMPUTER SYSTEM
U.S.A.

Magellan I is supplied *complete* with control/display unit (4" x 5" x 1.25"); premium-grade, high-resolution encoders for each telescope axis (encoder precision is 5.3 arc minutes); RS-232 serial interface; bracket for placement of the controller on the telescope tube; and attachment hardware. Just add the user-supplied 9v. transistor radio battery, and Magellan I is ready to use. First-time installation is quick and simple.

#2010: for Meade Starfinder Dobsonian
6", 8", 10", 12.5", or 16" . . . . $295.
Packing & shipping in the 48 states—$15.

STARFINDER DOBSONIAN TELESCOPES ***Shown with standard-equipment 5 x 24mm viewfinder and 1.25" rack-and-pinion focuser.***

All prices plus packing and shipping, as noted above.



6" f/8
$349

8" f/6
$449

10" f/4.5 $599
Shown with optional Magellan I Telescope Computer System

12" f/4.8
$895

16" f/4.5
$1195

MEADE STARFINDER EQUATORIALS

DC-powered drive systems for fully automatic tracking, and a wide range of standard-equipment features:

Professional-Grade Optical System: Includes hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

Precision Equatorial Mount: Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

Battery-Powered Cordless Drive System! Provides fully automatic tracking of celestial objects. Operates for more than 50 hours from 6 (user-supplied) AA-size batteries. Control panel also permits powering the telescope from 12v. auto cigarette lighter plug, using optional 25 ft. cord.

2" Giant Focuser: Meade #77 2" giant rack-and-pinion focuser is included as standard equipment, with eyepiece-holders for both 2" and 1.25" eyepieces.

Accessories and Components: #637 6 x 30mm viewfinder with wide 7° field; multi-coated MA25mm eyepiece (1.25"); strong, durable, spiral-wound optical tube with attractive white finish.

Starfinder Equatorial 16: Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6" dia. pier, and 6 x AA-size battery-powered worm gear drive; 8 x 50mm viewfinder; #77 2" giant focuser.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$65; 8"—$75; 10"—$90; 16"—$55 packing, shipped truck freight collect.

Meade Magellan Telescope Computer Systems

MEADE
ENTER
MODE
PREV
NEXT
ON
MAGELLAN I
TELESCOPE COMPUTER SYSTEM

Magellan I: Use the Magellan I computer to manually slew the telescope quickly to any of 12,218 database objects, or to any object of known R.A. and Dec. Specifications and object database are identical to Magellan I for Starfinder Dobsonians *(see facing page)*.

#2011: for Meade (DC-powered) Starfinder Equatorial 6", 8", or 10" . . . . $295.
#2012: for Meade (DC-powered) Starfinder Equatorial 16" . . . . 295.

MEADE
MAGELLAN II
COMPUTER • CORRECTOR
ENTER
MODE
FIND
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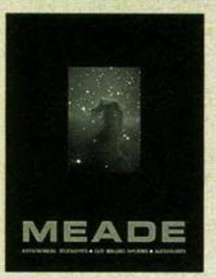
S

Magellan II Computer-Corrector: Plug the Magellan II into the control panel of your Meade Starfinder Equatorial and you have all the capabilities of the Magellan I, above, including 12,218-object database, *plus* a 4-speed (2x, 8x, 16x, 32x), dual-axis, drive corrector/microslewing system.

#2018: for (DC-powered) Starfinder Equatorial 6", 8", 10" . . 495.
#2019: for (DC-powered) Starfinder Equatorial 16" . . . . 595.

Packing & shipping in the 48 states: Magellan I–$15, Magellan II–$20.

Special Eyepiece Offer! At the time you order any Meade Starfinder Equatorial telescope, you can buy 2 additional multi-coated eyepieces, MA9mm and 12mm, ***for a total of $29.95!*** *Purchased separately, the 2 eyepieces sell for $75.90.*



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Orders & Information: 416-783-4140.

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World's Leading Manufacturer of Astronomical Telescopes for the Serious Amateur

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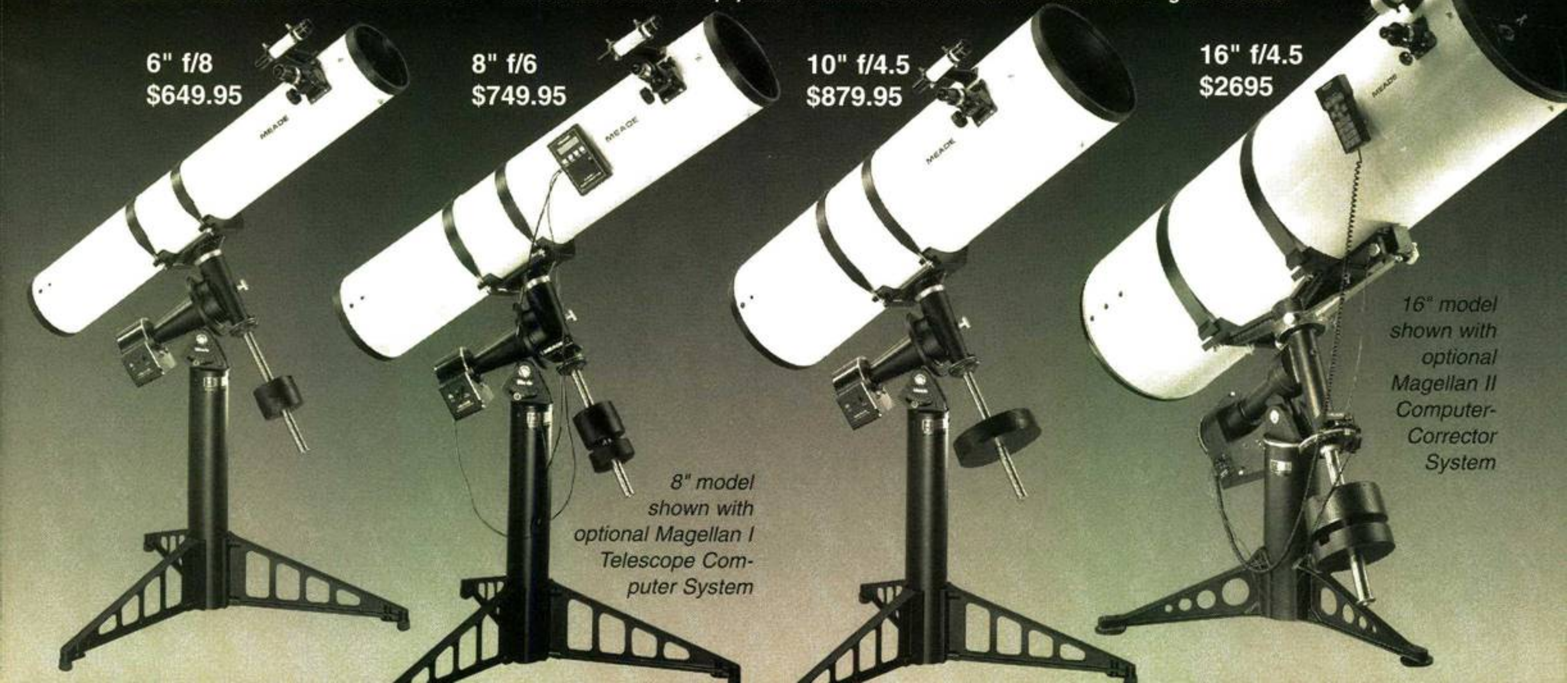
STARFINDER EQUATORIAL TELESCOPES ***Shown with standard-equipment 6 x 30mm or 8 x 50mm viewfinder and 2" giant focuser.***

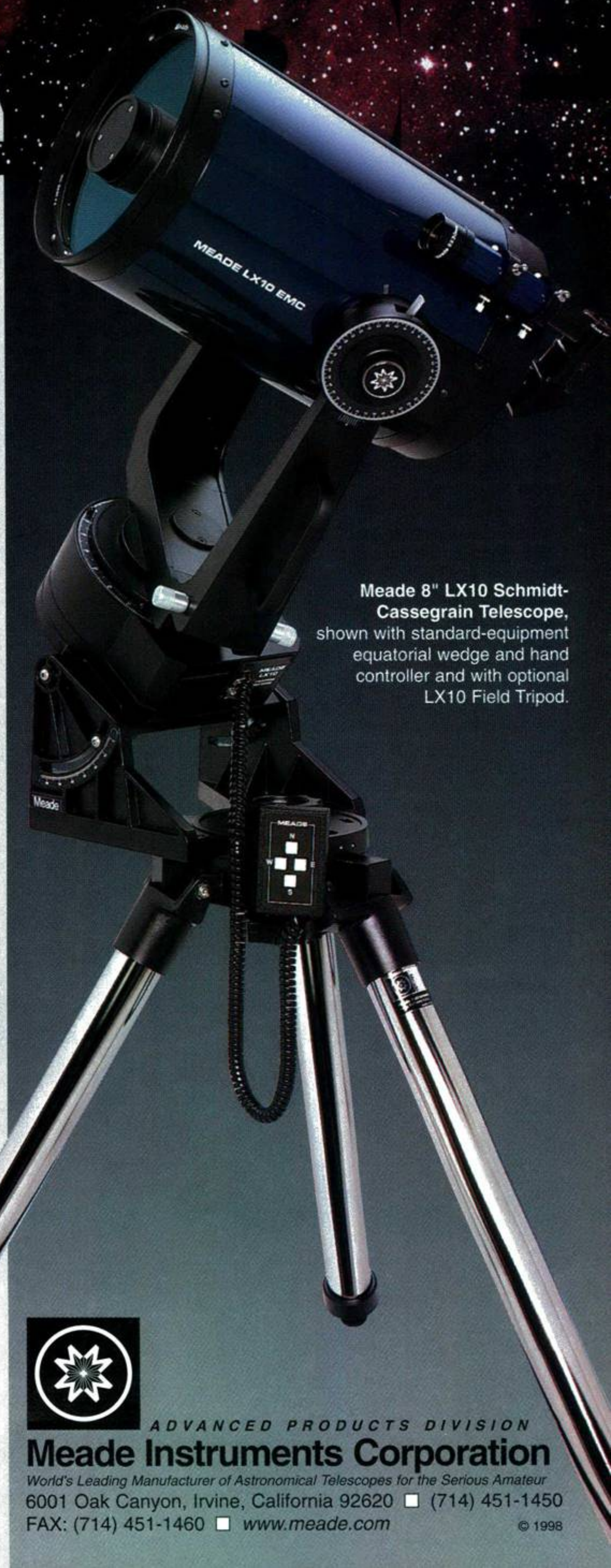


8" model shown with optional Magellan I Telescope Computer System

16" model shown with optional Magellan II Computer-Corrector System

8" LX10

8" LX10 DELUXE



Meade 8" LX10 Schmidt-Cassegrain Telescope, shown with standard-equipment equatorial wedge and hand controller and with optional LX10 Field Tripod.

The optical performance of a Meade 8" LX200 Schmidt-Cassegrain...for only *$995!*

8" LX10: For the serious amateur astronomer on a more limited budget, or for the more casual observer who nonetheless demands the very finest in optical performance, the Meade 8" LX10 satisfies every requirement. *Standard-equipment includes:*

Super Multi-Coated Optical System: The *exact same* multi-coated 8" Schmidt-Cassegrain optical tube assembly as more expensive Meade 8" LX50 and LX200 models. **Equatorial Fork Mounting:** The relatively light weight, but very stable, LX10 fork mounting provides all of the rigidity required for sensitive high-power applications of the telescope, or for photographic or CCD imaging. **Cordless, DC-Powered Electronic Motor Drive:** With electronically-regulated DC servo motor for automatic *sidereal-rate* tracking; powered by four AA-size batteries that fit conveniently through the telescope's control panel; battery life is in excess of 50 hours. **Worm-Gear System:** The LX10's 5.75"-diameter worm gear produces extremely smooth, regular motion in R.A., with low periodic error — a periodic error that permits such advanced capabilities as long-exposure astrophotography or CCD imaging. **Hand Controller:** Essential for micro-guiding the telescope during long-exposure astrophotography, the LX10's pushbutton hand controller enables precise corrections in R.A. at 2x speed. With the optional electric Declination motor added to the telescope, the hand controller is functional at 2x speeds on both telescope axes. Both the standard-equipment hand controller and the optional electric Declination motor plug into the telescope's control panel.

SPECIFICATIONS: 8" Model LX10 — Includes 8" Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings (D = 203mm; F = 2000mm, f/10); fork mount with setting circles, manual slow-motion controls, and locks on both axes; 5.75" LX worm gear reduction system; sidereal-rate electronically-regulated DC servo motor drive; 4-pushbutton hand controller for 2x speed corrections in R.A.; battery compartment accepting four (user-supplied) AA-size batteries (telescope may also be powered from an auto cigarette lighter plug, using optional 25 ft. cord); 6 x 30mm viewfinder; eyepiece-holder and diagonal prism (1.25"); MA25mm multi-coated eyepiece; standard equatorial wedge with elevation scale, fine elevation control, and 360° azimuth orientation capability; complete operating instructions. **$995.** (+ $65 packing & shipping in the 48 states)

8" LX10 Deluxe: At only $1149 the 8" LX10 Deluxe includes (a) the large-aperture Meade #544 8 x 50mm viewfinder (in place of the standard 6 x 30mm finder); (b) a premium-grade Meade Series 4000 Super Plössl 26mm eyepiece (in place of the standard MA25mm eyepiece); and (c) the LX10 Electric Declination Motor System, permitting dual-axis guiding corrections at 2x speed—all at substantially lower cost than if the respective accessories were purchased separately.

SPECIFICATIONS: 8" Model LX10 Deluxe — Identical in all specifications to 8" Model LX10, above, but with Electric Declination Motor System provided as standard equipment, permitting dual-axis corrections at 2x speed; and with Meade #544 8 x 50mm achromatic viewfinder and Series 4000 Super Plössl 26mm multi-coated eyepiece included in place of the 6 x 30mm viewfinder and MA25mm eyepiece of the LX10. **$1149.** (+ $65 packing & shipping in the 48 states)

Field Tripod for LX10 or *LX10 Deluxe* . . . . **195.**
***Electric* Declination Motor System** for LX10. . . . . **95.**
#2014 Magellan I Telescope Computer System for
LX10 or LX10 Deluxe,
with 12,218-object database . . . . **375.**

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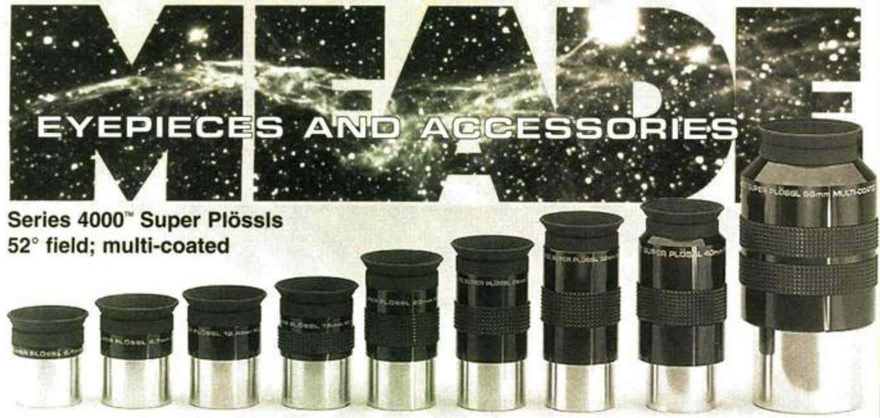


Series 4000™ Super Plössls
52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each:	**$79.95** (3.45)
32mm (52°); **40mm** (44°)	each:	**99.95** (3.79)
56mm (52°; 2")		**199.95** (5.48)

Series 4000™ Ultra Wide Angle
84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (3.94); **6.7mm: 199.95** (3.94); **8.8mm** (1.25"/2"): **239.95** (5.87); **14mm** (1.25"/2"): **299.95** (6.28)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (3.60)

Series 4000 Zoom Eyepiece

The first zoom eyepiece—ever—to yield absolutely uncompromised resolution, color correction, and image brightness. Includes 8 elements, zooms from 7.7mm to 23.1mm with pinpoint imaging from edge to edge. Fully multicoated optics permit 99.8% light transmission at each air-to-glass surface. Apparent field 62° at 7.7mm; fold-down rubber eyecup; threaded for filters; 1.25".

$295. (6.28)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (3.45)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (3.45)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

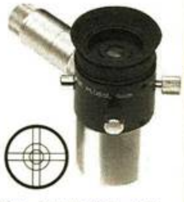
$59.95 (3.45)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.45)

World's Most Advanced Illuminated Reticle Eyepiece



Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (3.45)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (3.45)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue

each **$14.95** (2.29)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (2.98)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (2.98)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (2.98)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.29)

#905 Variable Polarizer (1.25")

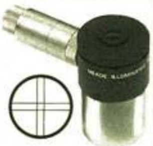
For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (4.27)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (3.45)

MA12mm Illuminated Reticle Eyepiece



Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Wireless red LED illuminator and variable brightness control. 1.25" **Batteries included.** **$99.95** (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (3.45)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

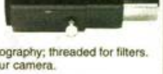
.965": $27.95; **1.25": $29.95** (2.98)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (2.98)

Variable-Projection Camera Adapter (1.25")



Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (2.98)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (2.98)

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

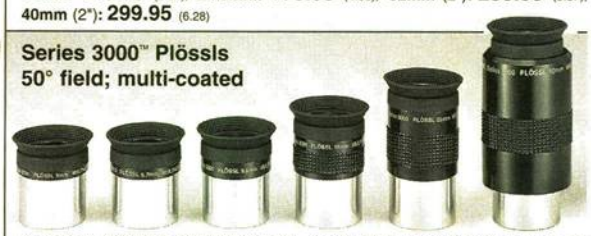
$79.95 (4.27)

Series 4000™ Super Wide Angle
67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (3.94); **18mm: 149.95** (3.94); **24.5mm: 179.95** (4.68); **32mm** (2"): **239.95** (5.87); **40mm** (2"): **299.95** (6.28)

Series 3000™ Plössls
50° field; multi-coated



Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm *(far right in photo)*, an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössls yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.45); **40mm** (44° field): **$79.95** (3.79)

#911B
#910B
#908B

#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (3.45)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95** (3.85)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (3.94)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (3.45)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95** (3.85)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (3.94)

#911X
New!
#910X
#908X

Series 4000 Oxygen-III Filter—Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade *60-layer* interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

#908X–Threads into 1.25" eyepieces, 26mm dia.	**99.95** (3.45)
#910X–Threads into 2" eyepieces, 44mm dia.	**159.95** (3.85)
#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**149.95** (3.94)

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TALKING BACK
FROM OUR READERS

Human Interest

I was pleased to read "Larger than Life" and "When the Apple Falls," profiles of David Schramm and Sir Isaac Newton, in the April 1998 issue. Biographical articles like these provide readers with a sense of history in the development of astronomy as a science.

Without such chronological perspective, amateur astronomers (like me) could loose sight of the triumphs and struggles in astronomical thought and discovery taking place over the course of decades and centuries. I especially liked the time periods covered — from the 17th-century revolution of thought in physics to modern-day cosmological theorizing.

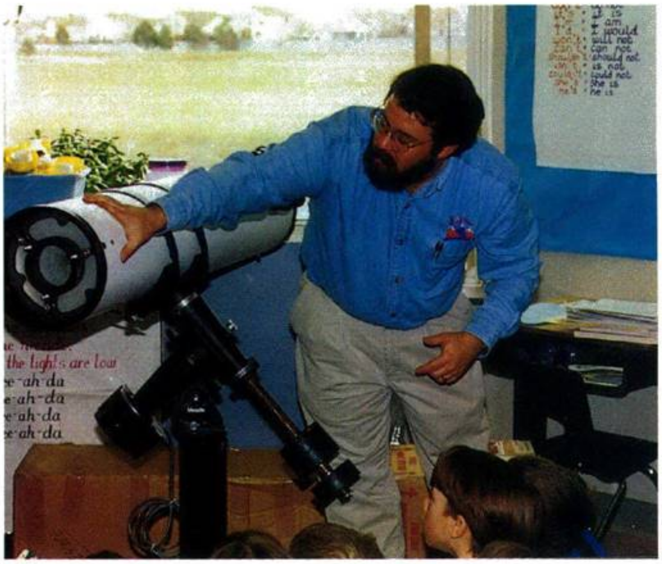
Please publish these types of articles in future issues. They provide interesting and exciting information bridging the past and the present. — *Randall Wehler, Wilmar, Minnesota*

I just read your fine tribute to David Schramm and had to add my two cents. I will remember Schramm because he took the time to share his enthusiasm with amateurs like me. I had the wonderful good fortune to attend five classes he taught at the Adler Planetarium in Chicago. I still find it amazing that someone of Dr. Schramm's caliber would take the time to teach a class to those whose only prerequisite was that they were interested enough to come and listen. He certainly didn't do it for fame or fortune. Schramm's classes were always well attended, and though I often didn't understand everything he was teaching us, his love and passion for cosmology was always extraordinarily clear. — *Br. Christopher Buck FSC, Westchester, Illinois*

The article incorrectly states that the opponents of Schramm's favorite theory deliberately coined the phrase "big bang" to be derogatory.

For my book *The Alchemy of the Heavens*, I interviewed Fred Hoyle, the big bang opponent who first used the term during a BBC broadcast nearly 50 years ago. "The BBC was all radio in those days," Hoyle told me, "and on radio, you have no visual aids, so it's essential to arrest the attention of the listener and to hold his or her comprehension by choosing striking words. There was no way in which I coined the phrase to be derogatory; I coined it to be striking, so that people would know the difference between the steady state model and the big bang model." This quote appears on pages 113 and 114 of my book.

Perhaps if Hoyle had been doing television instead of radio the term "big bang" would not exist today. — *Ken Croswell, Berkeley, California*



Greg Bell shares his telescope with enthralled second graders.

Barb Roisum

Parents in the Classroom

I had occasion recently to visit my son's second-grade classroom and teach the students about the planets. My son's teacher and I also arranged "activity centers" where the kids could look through my telescope and color in drawings of some of the planets. Judging from the oohs and aahs I'm not sure there could be a more fascinating subject for children. I must praise your magazine as well — your "3-D Blowout Issue" also served as an activity center. After the kids looked through my telescope, they donned 3-D glasses and pretended to float with the Space Shuttle or kick rocks on the surface of Mars. The best part for me was the thank-you notes I received later (complete with drawings) from each student — instant treasures. I would urge the entire family of *Astronomy* readers to volunteer for such work. It's really not work at all — I certainly feel like I received much more than I gave. — *Greg Bell, Little Rock, Colorado*

Kudos for Bob Berman

As a new subscriber to *Astronomy*, I must say that I was thoroughly impressed and amused by Bob Berman's "Easy Guide to the Sky" (May 1998). If more educators approached this subject with the sense of humor possessed by Berman, I am sure that interest in astronomy would soon be astronomical. My only hope is that Bob Berman will continue to be a regular contributor to *Astronomy*. — *R. L. Shereda, Las Vegas, Nevada*

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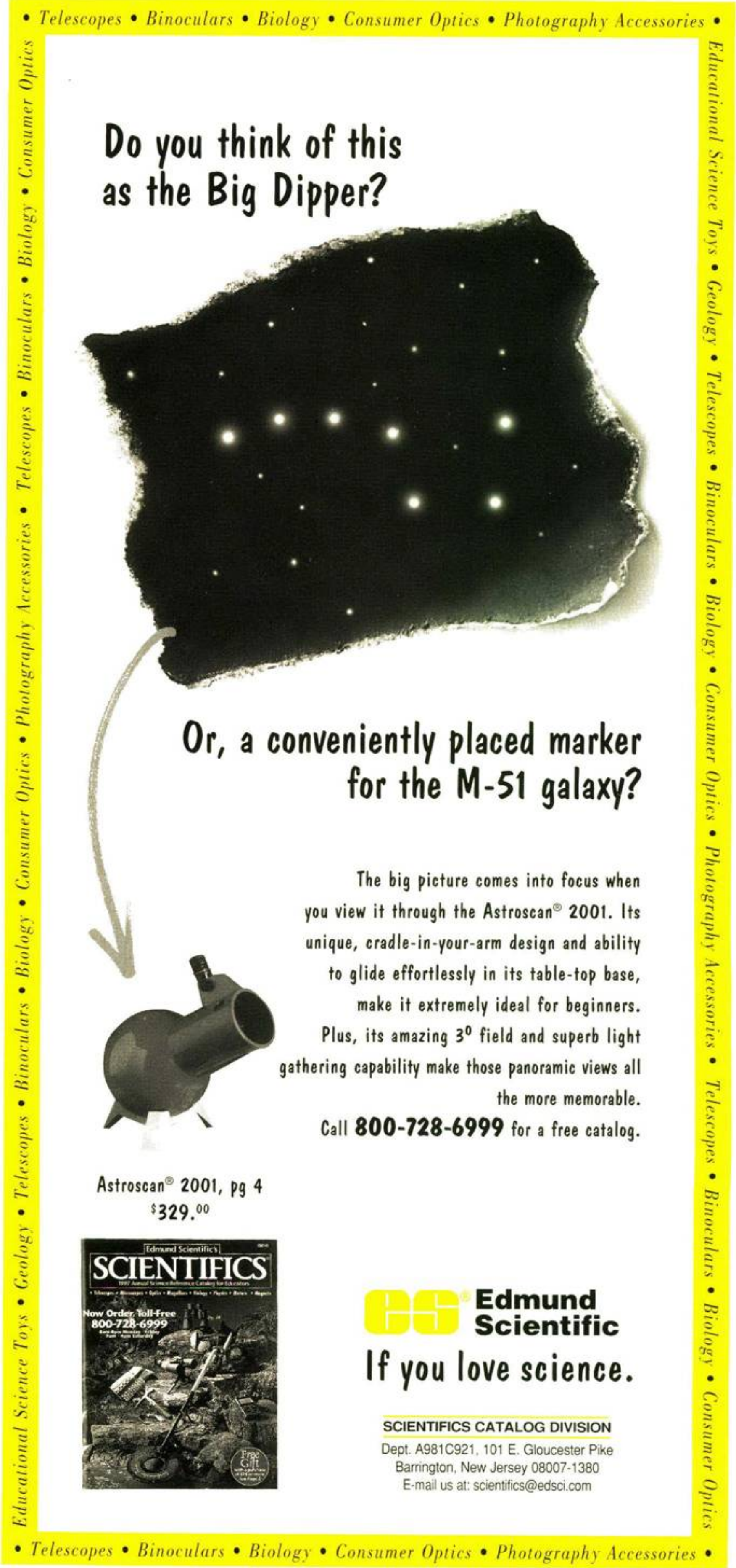

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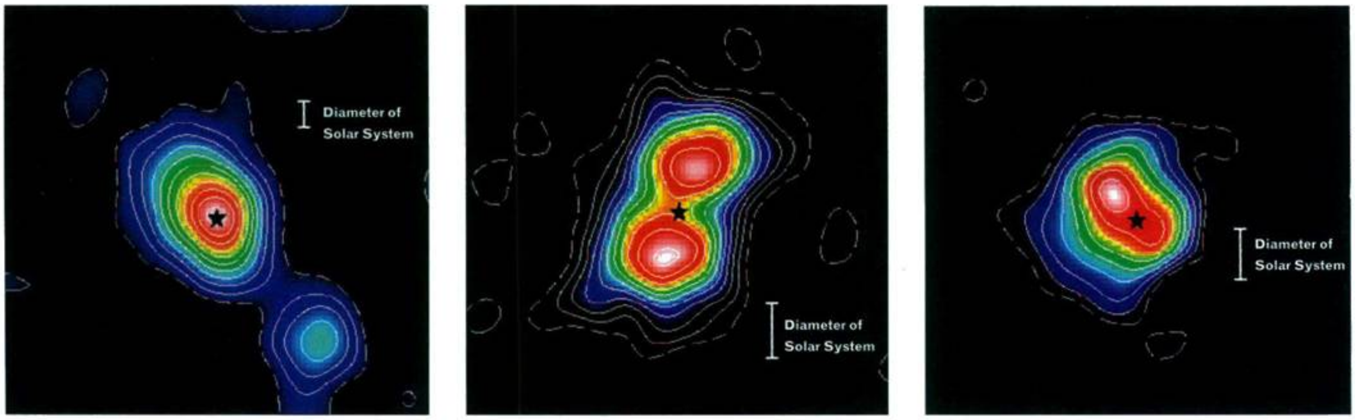
EXTRASOLAR PLANETS

Disks May Have Formed Planets



These radio images from the James Clerk Maxwell Telescope show disks of cold dust surrounding Beta Pictoris (left), Fomalhaut (center), and Vega (right). White corresponds to the peak dust concentration. The center of the Fomalhaut disk has a solar-system-size hole that was possibly "carved" by planets. The Beta Pictoris and Vega disks each have an unexplained clump of dust far from the star.

Wayne Holland (Joint Astronomy Centre), et al.

▶ Since the early 1980s astronomers have known that dozens of relatively young, nearby stars were surrounded by disks of cold dust particles. Astronomers strongly suspected that these disks represented debris leftover from the formation of planets. In 1983, they actually imaged one of these disks around the star Beta Pictoris. But for 15 years, that was it.

In just the last few months, however, astronomers have imaged disks surrounding the bright stars Vega and Fomalhaut, the solar-type star Epsilon Eridani (a mere 10.2 light-years away), and a more distant star known as HR 4796A. Intriguingly, the Fomalhaut, Epsilon Eridani, and HR 4796A disks are more akin to donuts than disks, with solar-system-size central cavities. "This is the signature of planet formation," says Wayne Holland of the Joint Astronomy Centre (JAC) in Hawaii, who notes that the cavities are exactly what astronomers would expect to see if planets gravitationally swept up the available material close to the stars.

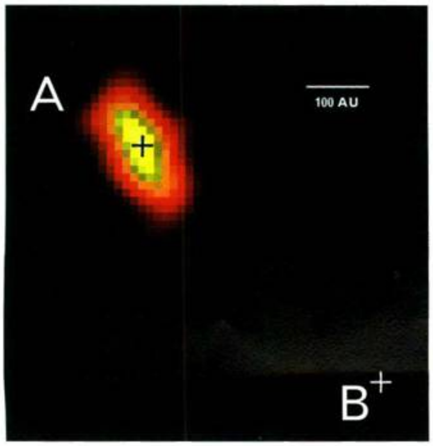
Holland led a group of JAC and UCLA astronomers who imaged the Vega, Fomalhaut, and Epsilon Eridani disks. The group used a revolutionary new camera called SCUBA coupled to the 15-meter James Clerk Maxwell Telescope on Hawaii's Mauna Kea. SCUBA's detectors are chilled to just 0.1° C above absolute zero. Minimizing background heat enabled the telescope to detect the extremely faint radio emission of cold (just 20° to 50° C above absolute zero) dust grains in the disks.

Besides the Fomalhaut and Epsilon Eridani cavities, SCUBA detected a mysterious blob of dust embedded within the Vega disk, and a similar blob in the Beta Pictoris disk. The blobs could be planets or brown dwarfs embedded in a dusty cocoon, although Holland points out that both blobs, particularly the one at Beta Pictoris, are considerably farther from their host stars than Pluto is from the sun. "The blobs are a real mystery," says Ben Zuckerman of UCLA. "They seem to be telling us something very surprising, but right now we have more questions than answers."

The HR 4796A disk was independently discovered by two teams, one led by Harvard University astronomer Ray Jayawardhana and the other by Michael Werner of NASA's Jet Propulsion Laboratory. The disk is about three times the size of the solar system and extends about one-fourth of the way to a smaller companion star, HR 4796B.

HR 4796A is about 10 million years old, considerably younger than Vega, Fomalhaut, Epsilon Eridani,

(see "Disks," p.18)



Two independent teams of astronomers co-discovered this disk of cold dust around the star HR 4796A. The disk has a central cavity that was possibly swept clean by planets. In this infrared image, the position of the primary star is marked A and the companion star is marked B. Our solar system probably looked like this 10 million years after the sun was born. Charles Telesco (University of Florida), CfA, and CTIO

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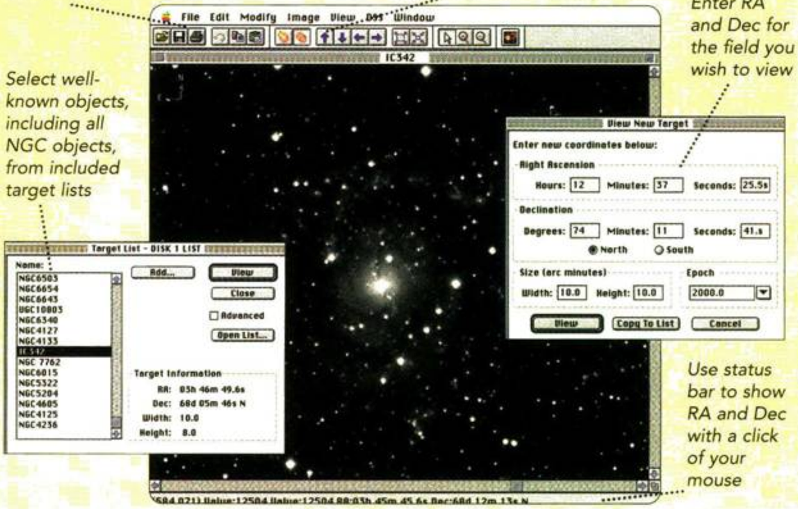

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Astronomical Society of the Pacific

GAMMA-RAY BURSTS

Stupendous Explosion Challenges Theory

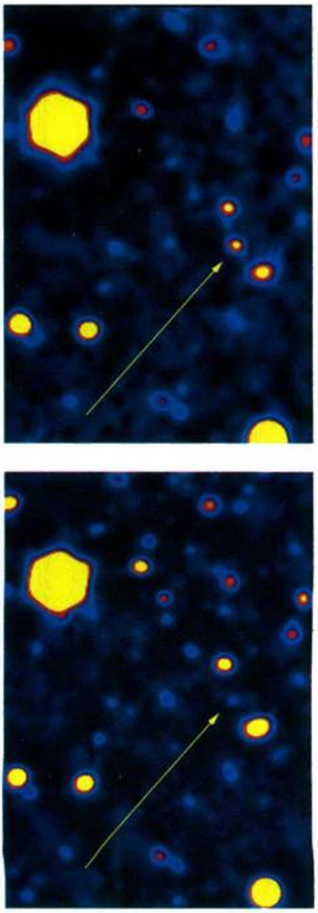
Step aside supernova, there's a new high-energy champ in town.

Astronomers have long known that gamma-ray bursts pack a wallop, but even they were stunned when they learned just how energetic these enigmatic events can be. The burst that changed their thinking occurred on December 14, 1997, when a flood of gamma rays washed over detectors on NASA's Compton Gamma-Ray Observatory and the Italian/Dutch satellite BeppoSAX. Within a couple of months astronomers had pinned down the burst's total energy and found that it dwarfed that of supernovae, exploding stars that until now were the most powerful phenomena known in the universe.

"The energy released by this burst in its first few seconds staggers the imagination," said Caltech astronomer Shrinivas Kulkarni, one of the principal investigators on the research team that determined the energy output. The team reported in the May 7 *Nature* that the burst was as luminous as the rest of the entire universe during those initial seconds, several hundred times the power output of a supernova.

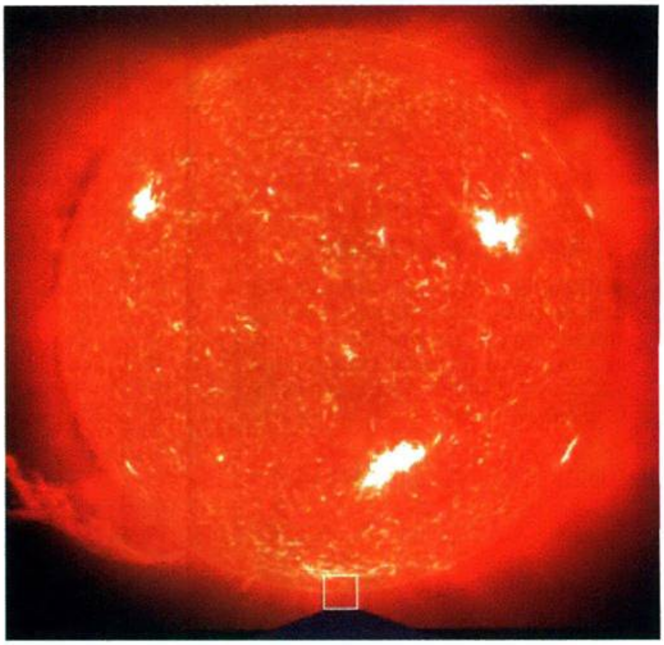
The key to calculating the burst's energy was in finding the burst's distance. BeppoSAX pinpointed the location in Ursa Major, allowing ground-based astronomers to search for an "afterglow" in visible light. Using the 10-meter Keck II Telescope on Mauna Kea in Hawaii, the Caltech team found the afterglow in an extremely faint galaxy. A spectrum showed that the galaxy lies at a redshift of 3.42, placing it some 12 billion light-years from Earth or more than 80 percent of the way back to the Big Bang.

(see "Explosion," p.20)



An intense gamma-ray burst this past December 14 had the energy of several hundred supernovae. The visible-light afterglow of the burst can be seen in an image taken with the 10-meter Keck II Telescope two days after the burst (top). Two months later the afterglow has faded away, revealing a faint galaxy lying some 12 billion light-years from Earth (bottom).

S. George Djorgovski and Shrinivas Kulkarni/W. M. Keck Observatory



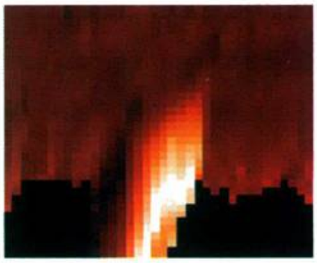
A tornado wider than Africa (right) gyrates from the South Pole of the sun. SOHO/EIT Consortium

(Disks)

and Beta Pictoris. The Hubble Space Telescope has imaged even younger disks in the Orion Nebula, but these disks are mostly gas, and planet formation in these disks is probably just getting underway. "The dust we see around HR 4796A adds up to about one Earth mass," says Jayawardhana. "That's 100 to 1,000 times less mass than we see in the Orion disks. So the implication is that the original material has gone somewhere, presumably into bigger bodies such as planets."

Both teams employed new infrared detectors to image the HR 4796A disk. Jayawardhana's team used the 4-meter Blanco Telescope in Chile while Werner's team imaged the disk with the 10-meter Keck II Telescope on Mauna Kea.

"The dust disks and holes around these stars strongly support the proposition that planets are likely to form," says San Francisco State University astronomer Geoff Marcy, who has co-discovered six planets outside the solar system.



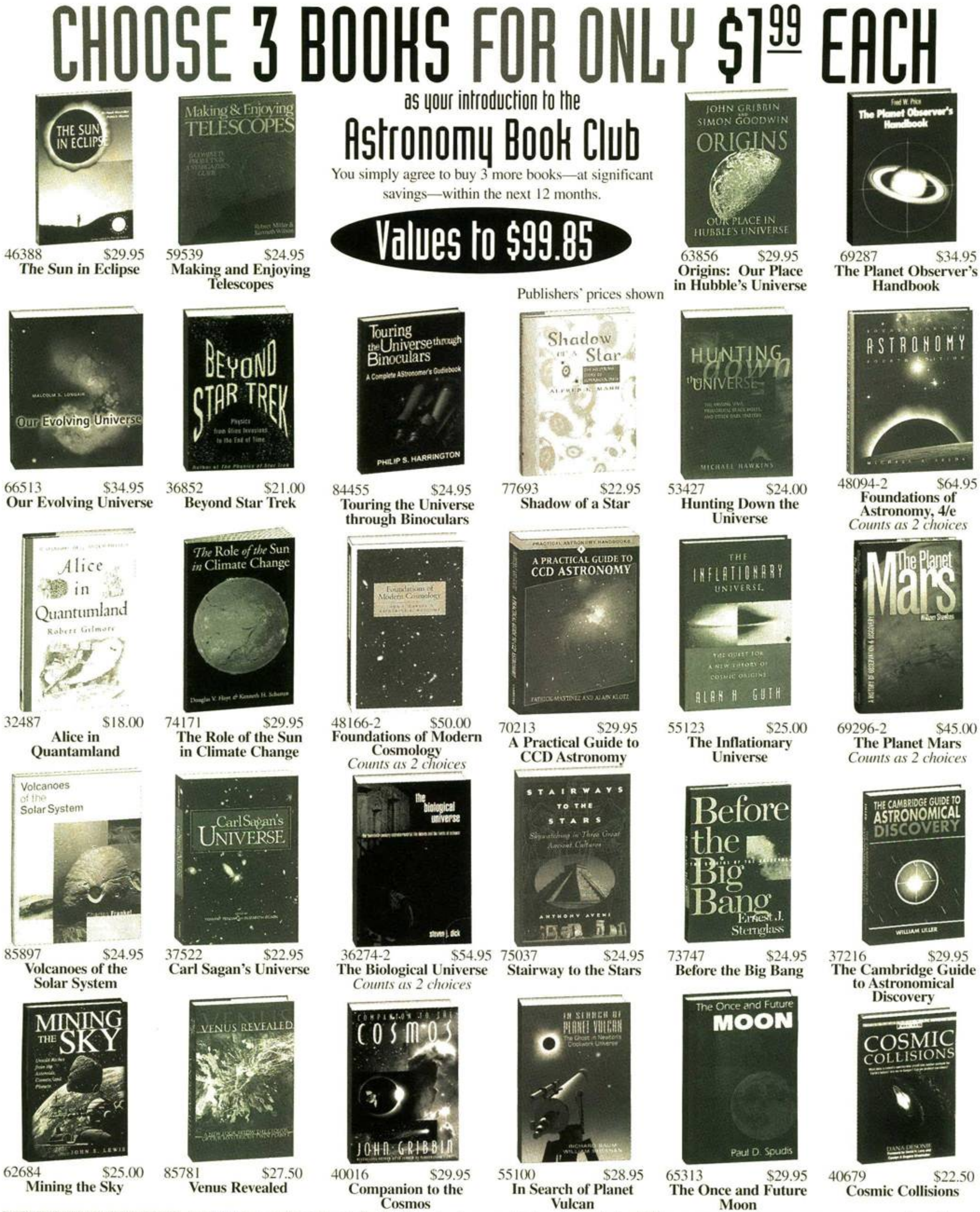
SOHO

Giant Tornados Spotted on Sun

British astronomers recently announced that the SOHO (the Solar and Heliospheric Observatory) satellite has spotted a total of 12 enormous solar tornados, twisters twirling up to 1,000 times the speed of the fastest funnel clouds on Earth.

The images of the solar tornados were constructed from data collected by one of SOHO's dozen instruments — a scanning spectrometer known as CDS. The device was used like a police radar gun to clock the speed of hot oxygen atoms. On one side of the solar twister the oxygen atoms race toward the detector at 30,000 miles (50,000 km) per hour and on the other side the oxygen atoms move just as fast away

(see "Tornados," p.20)



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Astronomy 8/98

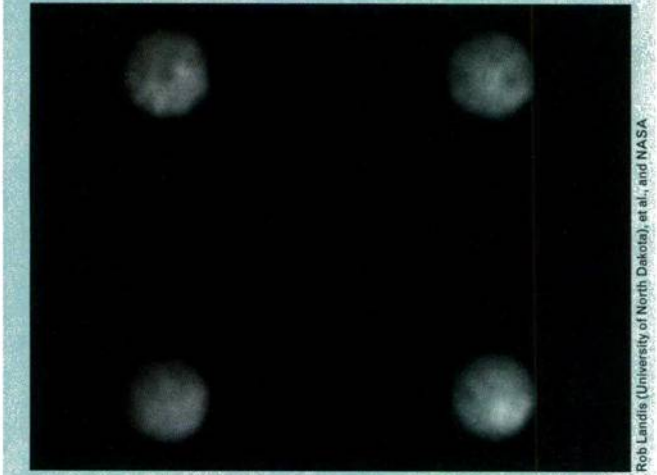
(Explosion)

Observations with the Hubble Space Telescope confirmed that the afterglow lies in this galaxy.

The chief question now is what could possibly create so much energy. One of the leading hypotheses held that gamma-ray bursts arise when two orbiting neutron stars spiral into each other and merge. But even the prodigious energy released in such a collision couldn't account for the December 14 burst except in the unlikely event that the entire mass of both neutron stars was converted to gamma rays.

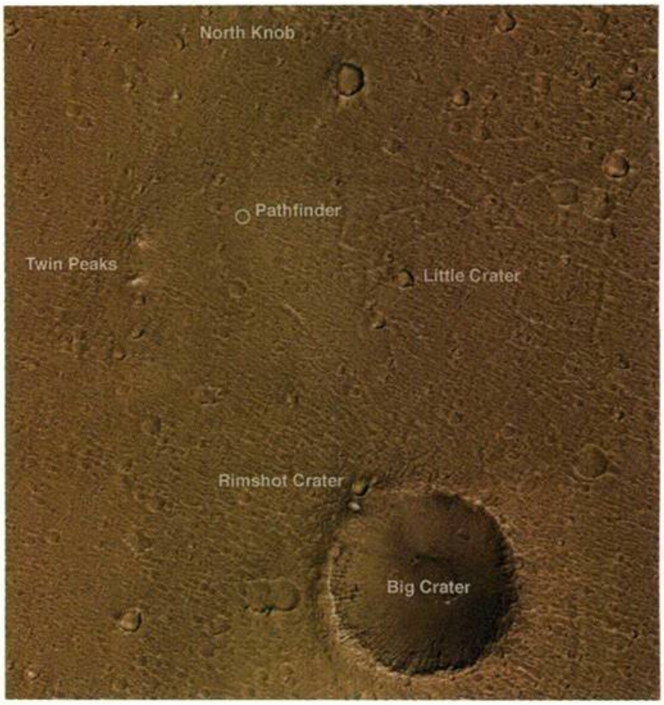
One possibility might be a "hypernova," a term coined by Princeton astronomer Bohdan Paczynski to describe what happens when an extremely massive star (containing 80 to 100 solar masses) explodes. But as Kulkarni says, "A gamma-ray burst is such an extreme phenomenon that it is possible we are dealing with something completely unanticipated and even more exotic."

ASTEROIDS



Rob Landis (University of North Dakota), et al., and NASA

HUBBLE SEES CERES **As has become commonplace, the Hubble Space Telescope has given astronomers their best view of yet another object. This time it is Ceres, the largest asteroid in the solar system. With a mean diameter of 579 miles (933 km), Ceres is nearly twice as big as the next largest asteroid, Pallas. The Hubble images show that Ceres is spherical, as astronomers would expect for an object of its size. The four views show two different "faces" of Ceres as it rotates over a 9.1-hour period; the top images were taken in ultraviolet light and the bottom in visible light. The images reveal light and dark splotches that correspond to large-scale surface markings. "The circular markings may be impact features," says Rob Landis of the University of North Dakota, "but we really don't know for sure what they are."**



NASA/Malin Space Science Systems

Mars Global Surveyor imaged the Mars Pathfinder landing site. Features only 21.5 feet (6.6 meters) across can be seen, but the resolution wasn't quite good enough to reveal the lander itself.

(Tornados)

from the detector. Those were just the steady wind speeds — CDS recorded gusts 10 times faster still.

David Pike of the Rutherford Appleton Laboratory and Helen Mason of Cambridge University reported that the tornados are nearly as wide as Earth. All 12 tornados surged from polar regions and may somehow contribute to the fast solar wind that emerges from polar cool spots called coronal holes.

"Physically they are different and their origins are very different from terrestrial tornados," says Pike. "The solar version forms low down in the atmosphere and spirals upward, so as far as we know, there is no real upper limit to their extent." Pike adds that as of now, nobody knows exactly how they form, although it could be related to twisted magnetic fields. "The energy stored in the twisted magnetic field is then released and drives the tornado, a bit like cutting a twisted rubber band," he says.

MARS GLOBAL SURVEYOR

Ancient Seas on Mars?

▶ Mars Global Surveyor's altimeter revealed that Mars's northern lowlands are unexpectedly smooth; some scientists say this supports the idea that the lowlands were once covered by ancient seas. Outside of the Tharsis volcanic bulge, topography typically varies only 160 to 1,300 feet (50 to 400 meters) over expanses of hundreds of miles. The elevation profiles from the hilly uplands down onto the smooth plains are remarkably similar to those on Earth from continental margins down onto smooth seafloor deposits. This similarity renewed discussion that the northern lowlands may be basins that were once filled at least partially with water early in Mars's history. Proof of such martian seas, however, *is still lacking.*

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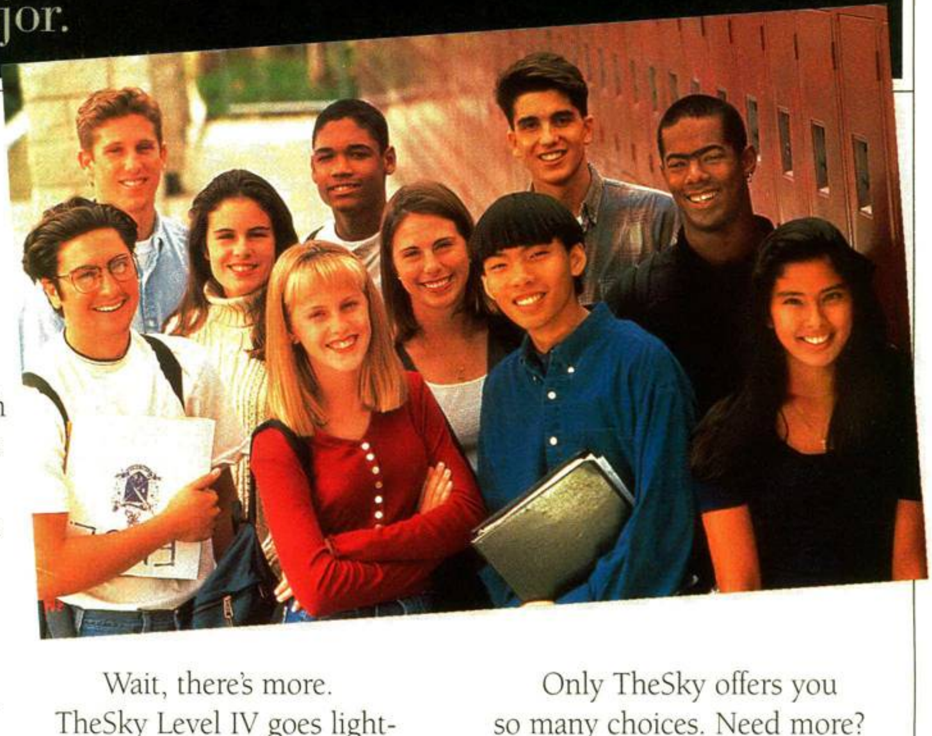

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depart from normal imaging and redirect the spacecraft to take pictures of the Pathfinder and Viking 1 and 2 landing sites, as well as the so-called "Face on Mars." This involved some extra expense and labor by the MGS science team. The "Face" and neighboring hills in the Cydonia region were revealed to be natural plateaus where resistant cap-rock layers eroded to form elevated plateaus with ridges and valleys that cast intricate shadow patterns.

Although MGS was unable to resolve the three landers, photos of the landing sites allow a bird's eye view of features once seen only from the ground. The Pathfinder site is moderately cratered, with many craters and hills partially engulfed in dust drifts. The famous Twin Peaks appear partly submerged in drifts, with only their summits protruding in steep slopes. This fits with Pathfinder photos that show a bright dust drift extending up the face of the southern peak.

All current MGS work is being done on a contingency basis because attaining the planned 250-mile-high circular orbit has been delayed until spring 1999. Despite the delay, the spacecraft remains in excellent health.

—William K. Hartmann,
Planetary Science Institute

GLOBULAR CLUSTERS

A Strange Brew in 47 Tucanae

▶ Globular clusters are not the chemically homogeneous collection of stars astronomers once thought they were. Using the 4-meter Blanco Telescope in Chile, Michael Briley of the University of Wisconsin at Oshkosh and colleagues have found large differences in the sodium (Na), cyanogen (CN), and methylidyne (CH) abundances of low mass stars in 47 Tucanae, and more recently, in NGC 6752 in Pavo.

Globular clusters are huge, nearly spherical star aggregations that are some of the oldest objects in the galaxy (roughly 12 to 14 billion years). They are scattered throughout the Milky Way's halo, and are believed to have formed from small concentrations of primordial gas in the early universe. Stars within an individual globular cluster share a common history and are thought to differ only by their mass. Because the speed at which they evolve is related to their mass, "These stars give us an indication of when the galaxy formed, and consequently a minimum age of the universe," says Briley.

The chemical differences might be due to supernovae that occurred early in a globular's history. Such explosions could have polluted the material from which the stars formed. If true, some of a globular's stars must have evolved and exploded before star formation was finished. But there's a problem: Most globulars don't have enough mass to retain supernova ejecta, which are enriched with heavy elements.

Contrary to expectations, 47 Tucanae's low mass stars vary in chemical composition. Michael Stecker

Alternatively, the stars may have modified their own surface compositions by churning up heavier elements such as carbon, nitrogen, and possibly sodium from their cores, where they are created by nuclear fusion of lighter elements. "If this material is being brought to the surface, something must be missing from our standard theories of the structure and evolution of low-mass stars, as they do not predict this mixing," says Briley. "By understanding the early environment in which these old, low-mass stars formed, we can better understand the very nature of the early universe."

LUNAR PROSPECTOR

Lunar Ice Called into Question

▶ Alan Binder made a splash on March 5 when he announced that Lunar Prospector's neutron spectrometer had found the "signature one would expect . . . if water ice is present" at the moon's poles. Binder was even more forthright addressing planetary scientists at the Lunar and Planetary Science Conference in Houston on March 19: "The water issue is answered. We know it is there."

Although the mass media embraced lunar ice wholeheartedly, Binder's confidence grated on many in the lunar science community, including geologist and Apollo 17 moonwalker Harrison Schmitt. In April, Schmitt, now a professor at the University of Wisconsin, branded Binder's statements as "premature assumptions."

Schmitt points out that Lunar Prospector cannot detect water directly — the existence of water ice is an inference based on modestly elevated hydrogen levels at the poles. Schmitt and several colleagues do not question Lunar Prospector's data, but they have their own theory to account for it. They say that polar hydrogen indicates that solar wind hydrogen has been trapped in permanently shadowed craters. Schmitt speculates that NASA sees lunar ice as "better PR." "We want to be sure that NASA and the Lunar Prospector team don't talk themselves into something that isn't there," he says.

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Binder admits that "water is not the only answer," adding that his and Schmitt's interpretations are clearly "going toward preferences." He says Schmitt prefers trapped hydrogen because he advocates mining lunar helium-3 as fuel for future fusion reactors. Trapped hydrogen implies trapped, concentrated solar wind helium-3, improving mining feasibility. Binder sees ice as the key to lunar cities. "Settlement is what it's all about," he says.

Schmitt and Binder agree that more study is necessary. Says Schmitt: "We will do everything we can to make sure NASA supports Lunar Prospector data analysis," despite budget pruning. Binder, meanwhile, is seeking private sector funds for a follow-up mission.

—DAVID S. F. PORTREE

COMET HALE-BOPP

Baby Bopps?

▶ Although Comet Hale-Bopp continues to fade from view, its impact on astronomy does not. At a recent conference held in the Canary Islands, more than 150 comet experts gathered to discuss a host of new discoveries. One of the most controversial items concerned the very heart of the comet: its nucleus. Zdenek Sekanina of the Jet Propulsion Laboratory reported that Hale-Bopp may have spawned one or more satellites during its recent passage.

Sekanina analyzed a set of high-resolution Hubble Space Telescope images using software he wrote to remove the dusty veil of Hale-Bopp's inner coma, so that the comet's nucleus itself could be studied. Sekanina found several bright, unresolved points of light near the nucleus. The number and positions of these point sources changed from image to image.

Hubble tracked on the comet so its images would be as sharp as possible and stars would be trailed and not point-like. So Sekanina concludes that some, or all, of the bright points could be satellites of the comet. The satellites were presumably dislodged from the nucleus due to its high rate of activity. Sekanina estimates that the largest of the point sources could be half the roughly 25-mile (40 km) diameter of the nucleus itself.

Most comet experts remain skeptical, in part because other Hubble images of Hale-Bopp are devoid of evidence for potential satellites. Is it possible that Sekanina's point sources were created by the crisscrossing of jets and geysers? Sekanina stands by his claim.

Whether or not Hale-Bopp spawned a gaggle of baby Bopps, comets are known to fragment. Paul Weissman of JPL has studied records of cometary fragmentation for more than 15 years. He estimates that significant splitting or fragmentation is seen from one in every 10 to perhaps one in every seven comet apparitions.

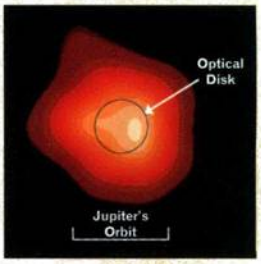
—S. ALAN STERN, SOUTHWEST RESEARCH INSTITUTE

Comet Hale-Bopp may have sprung small satellites or "baby-Bopps." Michael Stecker

Uranus Satellites Get Shakespeare Touch

Although Sycorax and Caliban are not Shakespeare's most famous characters, they may soon join a few of their literary brethren in orbit around Uranus. Brett Gladman of the University of Toronto and his colleagues, who discovered two new uranian moons in September 1997 (see February 1998 issue, page 26), have proposed naming them after the witch Sycorax and her beastly son Caliban from Shakespeare's play *The Tempest*. The names likely will be approved by the International Astronomical Union, which assigns official names to all objects and features beyond Earth.

Bulges on Betelgeuse



A high-resolution radio image shows Betelgeuse's outer atmosphere extending far beyond the disk resolved in visible light (circled). NRAO

Radio observations from the Very Large Array in New Mexico resolved large irregularities in the outer atmosphere of the red supergiant Betelgeuse, the brightest star in Orion. The bulges are probably due to enormous plumes of cool gas rising from the interior. "This alters our basic understanding of red supergiant star atmospheres," says team leader Jeremy Lim of the Academia Sinica Institute of Astronomy and Astrophysics in Taiwan.

Bad Stars

An Illinois company known as the International Star Registry (ISR) boasts on its web page that it has sold what investigators say is worthless astronomical property to President and Hillary Clinton, Mick Jagger, Yoko Ono, and Oprah Winfrey. Actually, thousands of people have paid $45 to ISR for the privilege of naming a star. Of course, astronomers know that the International Astronomical Union (IAU), not ISR, officially names stars. After ISR radio ads aired in New York, investigators with the city's Department of Consumer Affairs cited ISR for "engaging in a deceptive trade practice." The company faces a fine of $3,500 or more. No word yet from Kenneth Starr on this scandal.

Ulysses Completes Solar Orbit

The joint NASA-European Space Agency solar probe Ulysses has completed its first circuit around the sun. The spacecraft has covered 2.4 billion miles (3.8 billion km) during its 7.5-year journey that carried it high over the sun's poles. As solar cycle approaches its peak in 2001 or 2002, Ulysses continues to return valuable data about cosmic rays, the sun's magnetosphere, and the solar wind.

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M109 (NGC 3992) *is a 10th magnitude type FBb barred spiral galaxy located approximately 400 SE of Gamma Ursae Majoris and is approximately 6.40 x 3.50 in size. This ST-5C image is a composit of three 10 minute exposures co-added with CCDOPS and sharpened with CCDSHARP. Taken through a 10" f/4 telescope.* Courtesy Mike Barber/SBIG

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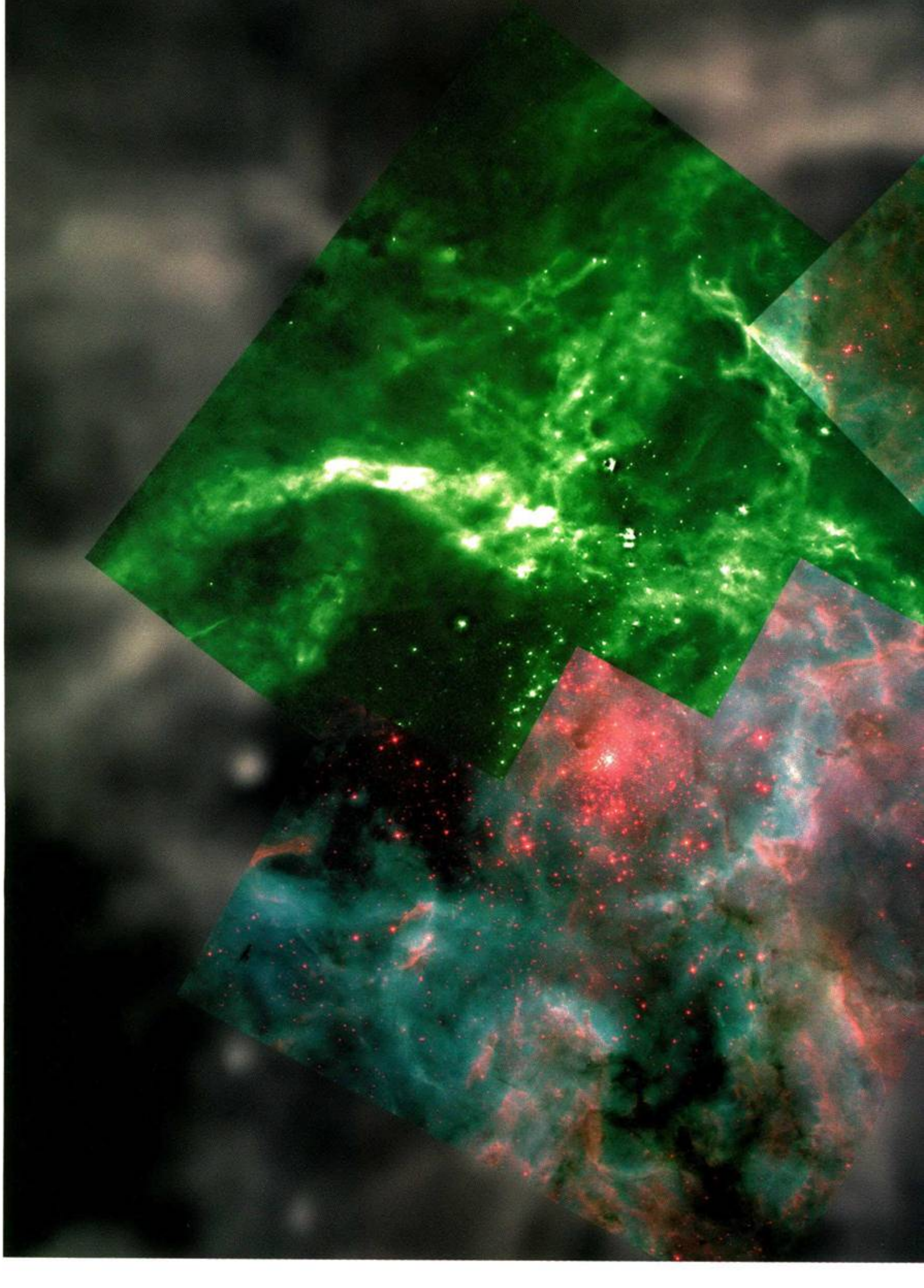

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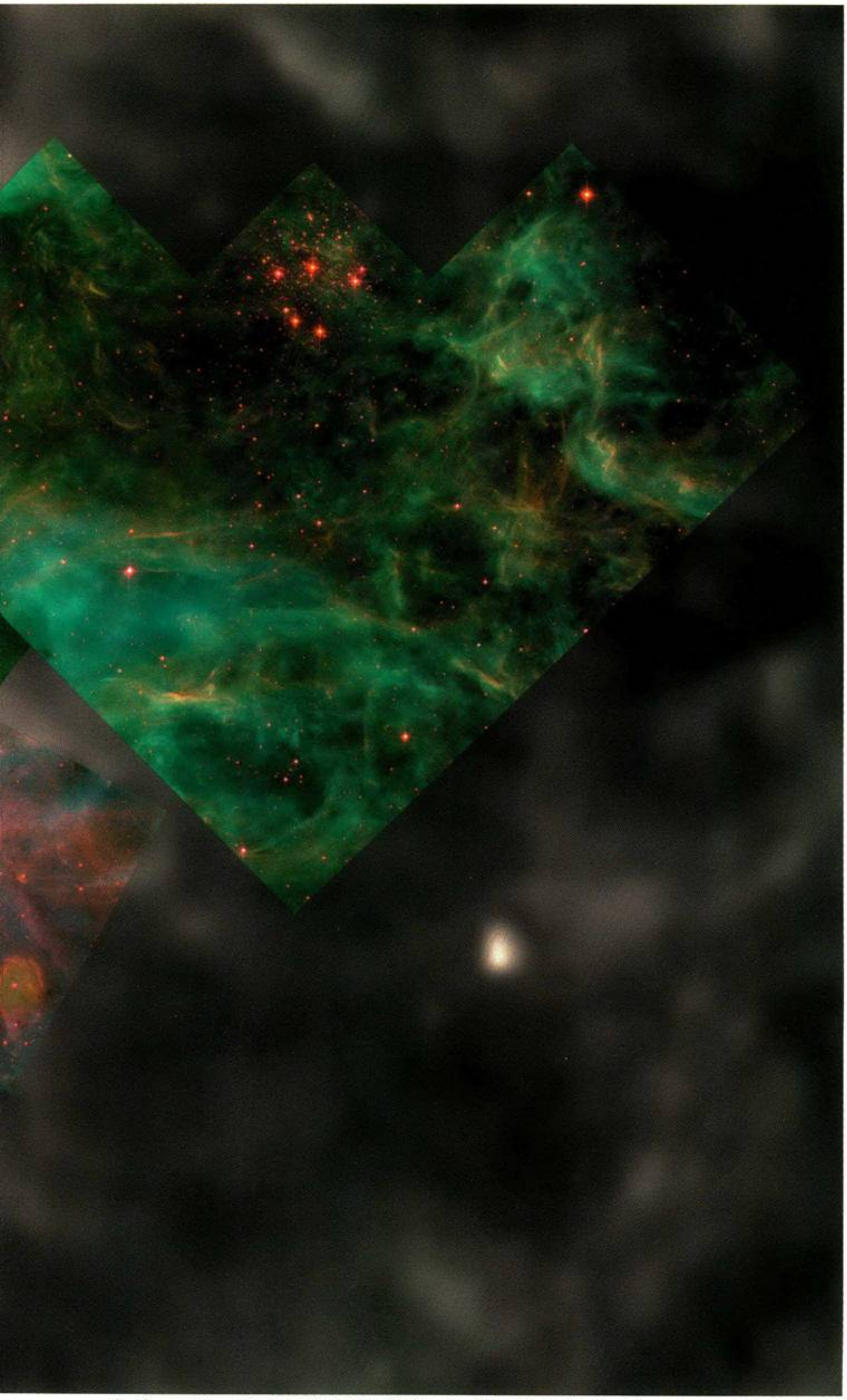


Paul Scowen (Arizona State University), You-Hua Chu (University of Illinois), Deidre Ann Hunter (Lowell Observatory), et al., and NASA

by Robert Naeye

They say a picture is worth a thousand words. While this cliché often rings true, some pictures are worth more than others. Consider the famous Hubble Space Telescope image of the Eagle Nebula's majestic gas pillars (see page 63). How many words is that picture worth?

Readers of this magazine are used to spectacular astrophotos taken by amateurs and professionals alike. But nothing can quite match the sheer impact of the best Hubble images. While many professional telescopes have much larger apertures than Hubble's 2.4-meter mirror, Hubble is perched high above the distorting effects of Earth's atmosphere. This gives it the exquisite resolution that bedazzles the general public while simultaneously advancing the frontiers of knowledge. Says Arizona State University astronomer Paul Scowen, "With Hubble, we get such a clearer view of the universe that every time you get a picture of something outside the solar system, it is humanity's best view of that object, period."

Hundreds of beautiful Hubble images have graced the pages of this magazine and others. But astronomers have taken 140,000 exposures with the Hubble Space Telescope, only a tiny fraction of which have been released to the general public. A treasure trove is out there waiting to be mined. We thought *Astronomy*'s silver anniversary issue offered a perfect excuse to publish some of the best Hubble images we could get our hands on — either newly released images or ones that have not yet been publicly released.

An astronomer (or more often, a team of astronomers) who takes a picture with Hubble has proprietary rights to that image for exactly one year. This policy allows the astronomer to study the data for a full year and publish new findings without fear of being scooped by competing researchers. But after that year is up, the image goes into a public archive where anybody can look at it. After all, it's the taxpayers who foot the telescope's bill, so you have as much right to view these images as a Ph.D. astrophysicist.

Art or science? This montage of three Hubble images shows the inner regions of 30 Doradus (the Tarantula Nebula), a gigantic star forming region in the Large Magellanic Cloud.

Once an image goes public, the Office of Public Outreach at the Space Telescope Science Institute (STScI) decides whether to issue a press release. As STScI's news chief Ray Villard notes, "There is more interesting stuff coming out of Hubble than there are hours of the day to deal with."

Much of Hubble's time is spent taking spectra rather than images. As an old astronomy adage goes, if a picture is worth a thousand words, a spectrum is worth a thousand pictures. "The spectroscopic work has been overlooked by the public, but it's been at the forefront of understanding the dynamics of various objects, such as determining the masses of black holes in galactic centers," says Villard.

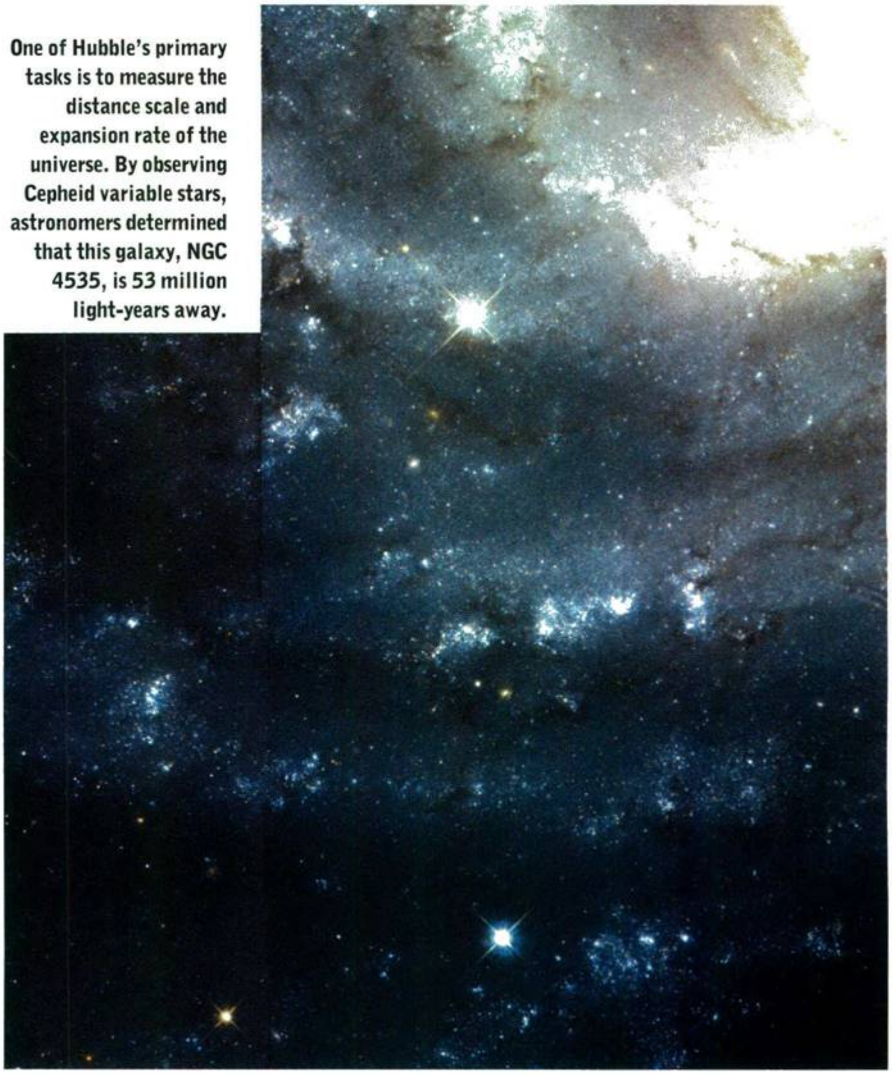
While Hubble has a variety of instruments and cameras, the vast majority of publicly released pictures (including just about all the ones in this article) were taken by the Wide-Field/Planetary Camera 2, which was installed by space shuttle astronauts in December 1993 to help correct optical flaws in the primary mirror. The camera, affectionately known as WFPC2 (wiff-pick 2), takes pictures in visible light and has a larger field of view than other Hubble cameras. Its one major shortcoming is the blank, bat wing-shaped region in the corner of many images. WFPC2 consists of three CCD chips for the Wide-Field Camera and one CCD chip with slightly sharper resolution but a smaller field of view (the Planetary Camera). Originally, WFPC2 was to consist of two cameras, one with four Wide-Field Camera chips and one with four Planetary Camera chips. But escalating costs prevented the camera's completion, leaving WFPC2 in this odd configuration.

Later this year STScI hopes to kick off the Heritage program, which is specifically tailored to bring the most beautiful unreleased images in the Hubble archive to the general public. STScI plans to release about one image per month on a special website.

Villard says the STScI staff is particularly excited about a new camera that will be installed on Hubble in 2000, the Advanced Camera for Surveys. This camera will combine a wider field of view and sharper resolution than WFPC2 and a full square-shaped image. "It should knock the socks off nearly everything we'd imaged previously," says Villard.

The Space Telescope has cost $4 billion to date. That's about $1 per year per American taxpayer since the program was initially funded in 1978. We hope you feel you're getting your money's worth — not just for the pretty pictures, but for the knowledge humanity is gaining about the wondrous universe we inhabit.

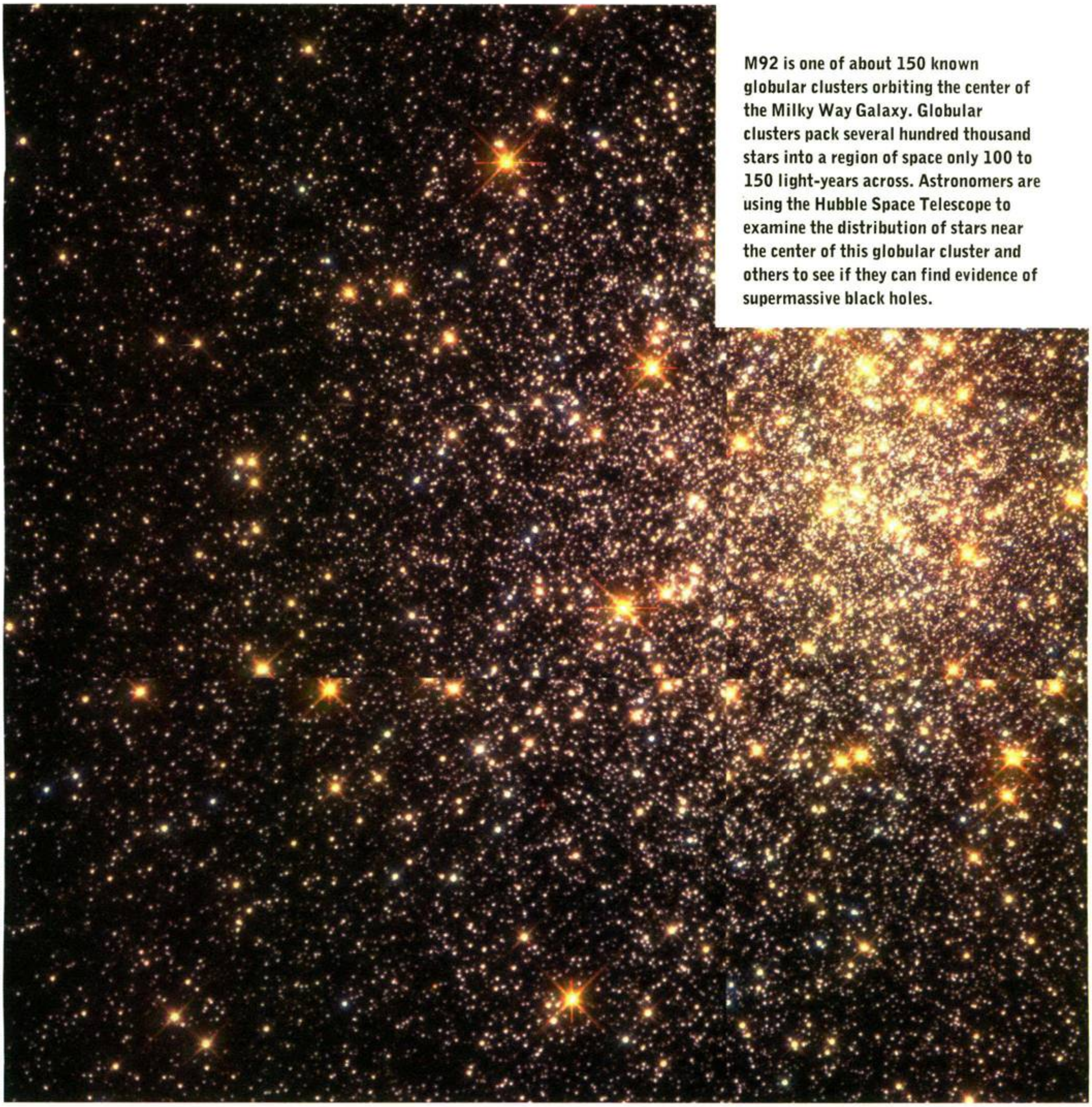
One of Hubble's primary tasks is to measure the distance scale and expansion rate of the universe. By observing Cepheid variable stars, astronomers determined that this galaxy, NGC 4535, is 53 million light-years away.



Lucas Macri (Harvard University), the HST Key Project, and NASA

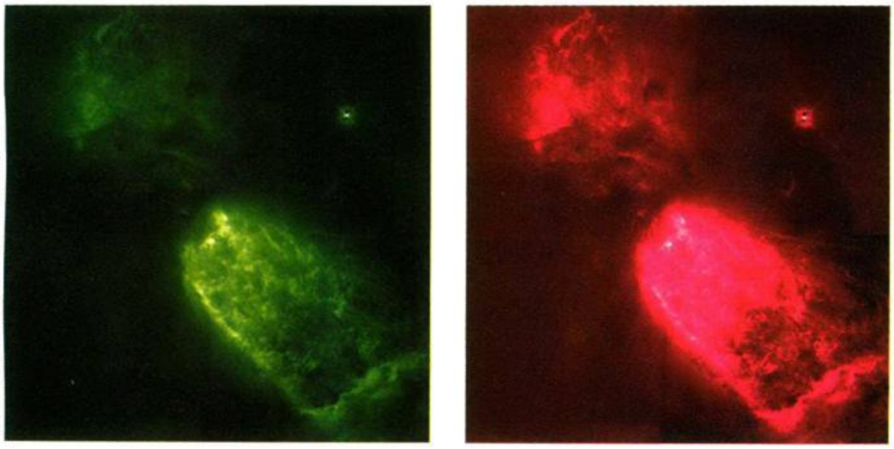
Some of Hubble's most glorious images show planetary nebulae — the gaseous death shrouds of stars like the sun. This image shows NGC 6537, also known as the Red Spider Nebula.

Bruce Balick (University of Washington), et al., and NASA



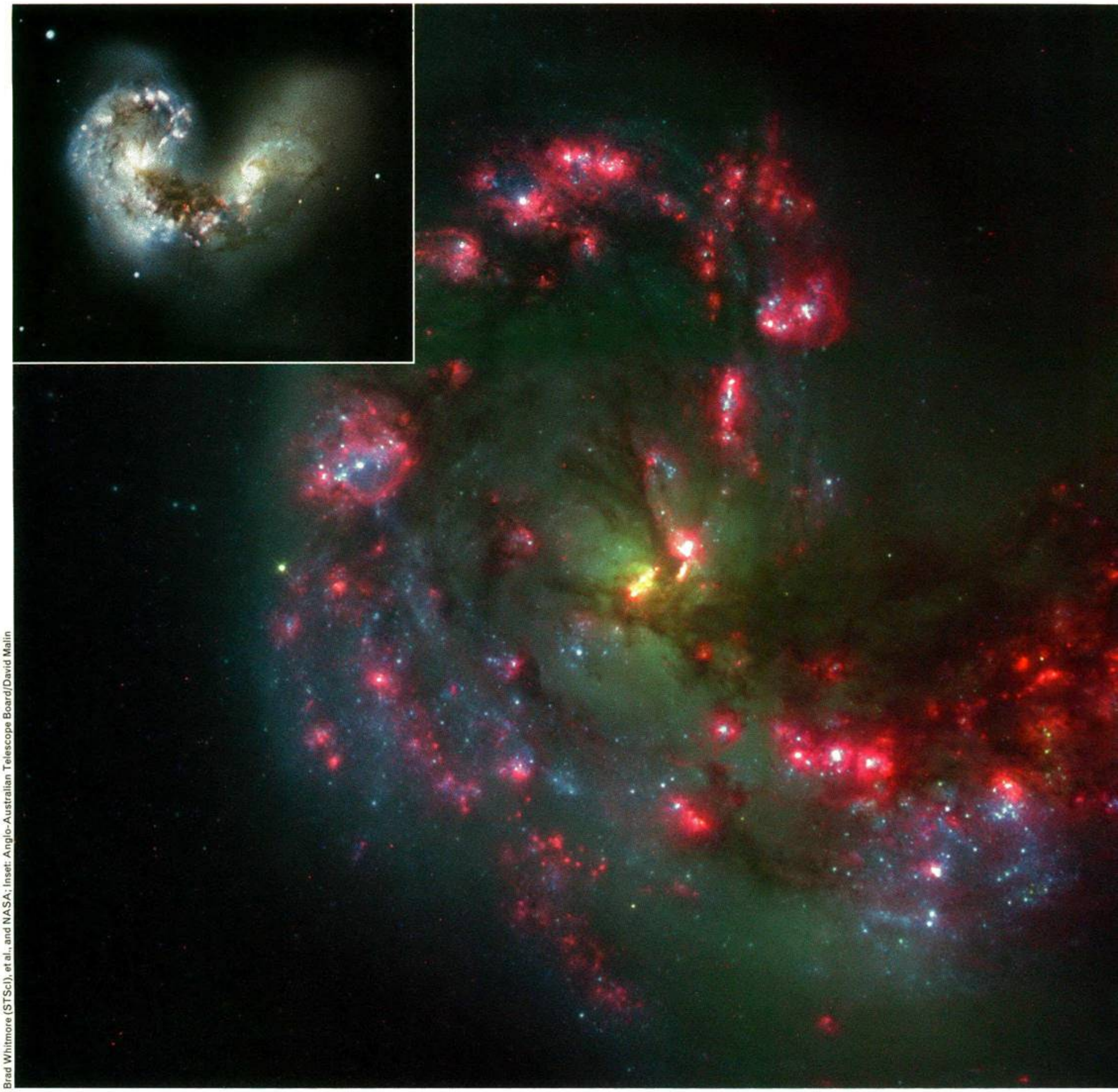
M92 is one of about 150 known globular clusters orbiting the center of the Milky Way Galaxy. Globular clusters pack several hundred thousand stars into a region of space only 100 to 150 light-years across. Astronomers are using the Hubble Space Telescope to examine the distribution of stars near the center of this globular cluster and others to see if they can find evidence of supermassive black holes.

John Bahcall (Institute for Advanced Study), Don Schneider (Penn State University), and NASA



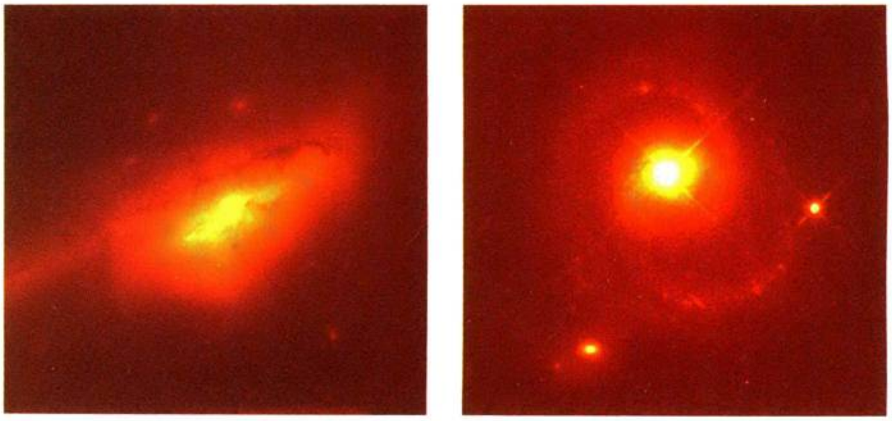
These Hubble images show S106, a gaseous bubble being sculpted by the winds of a massive young star, which is embedded in the dark lane between the two lobes of the nebula. The two images show exactly the same field but were computer processed in different colors. The red version is closer to what the human eye would see.

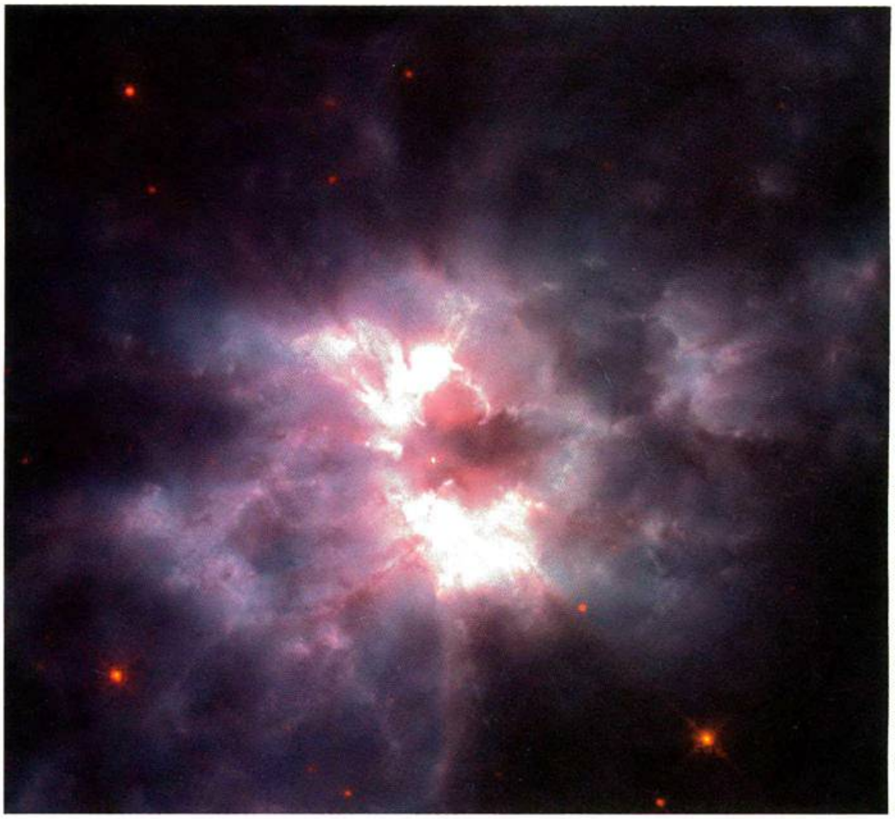
Ka Chun Yu (University of Colorado), et al., and NASA



Brad Whitmore (STScI), et al., and NASA; Inset: Anglo-Australian Telescope Board/David Malin

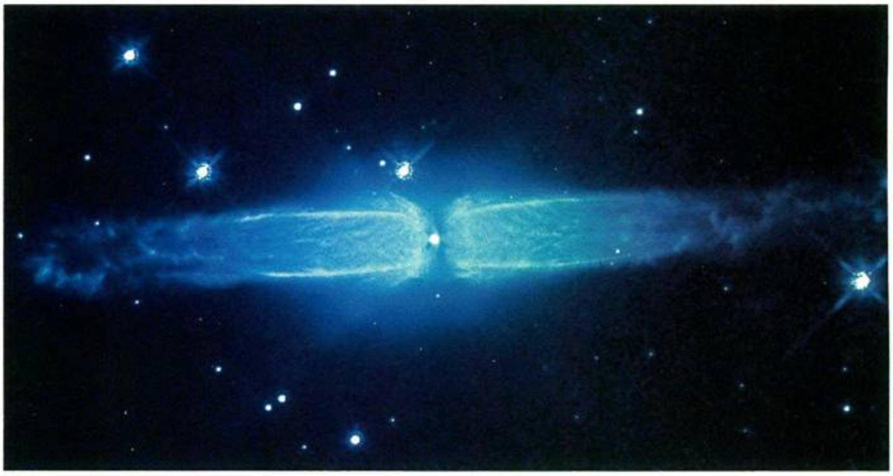
ABOVE: Hubble's false-color image of the Antennae (NGC 4038 and NGC 4039) reveals regions of explosive star formation (reddish areas) that occur when two large galaxies collide. A ground-based image is shown in the inset. **RIGHT:** These galaxies are all about one billion light-years away. All four are much more luminous than typical spiral galaxies, probably due to extreme star formation that is triggered by galactic mergers.



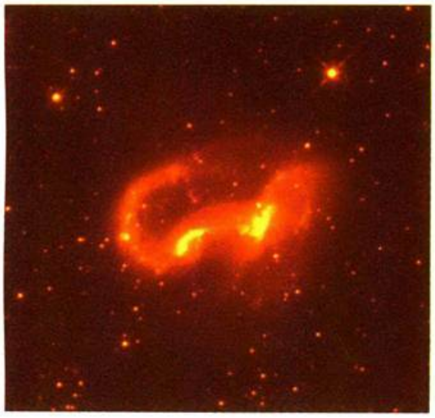


Howard Bond (STScI), Robin Ciardullo (Penn State University), and NASA

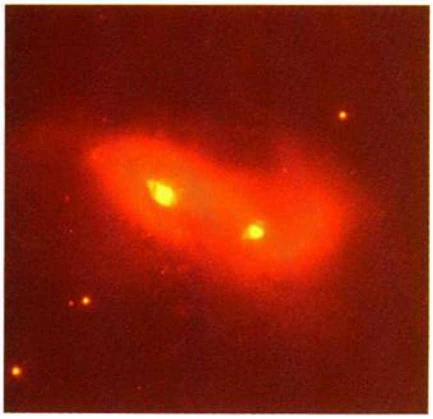
The dying central star of planetary nebula NGC 2440 is one of the hottest known stars, with a surface temperature of 200,000 kelvins. For comparison, the sun's surface is 6,000 kelvins.



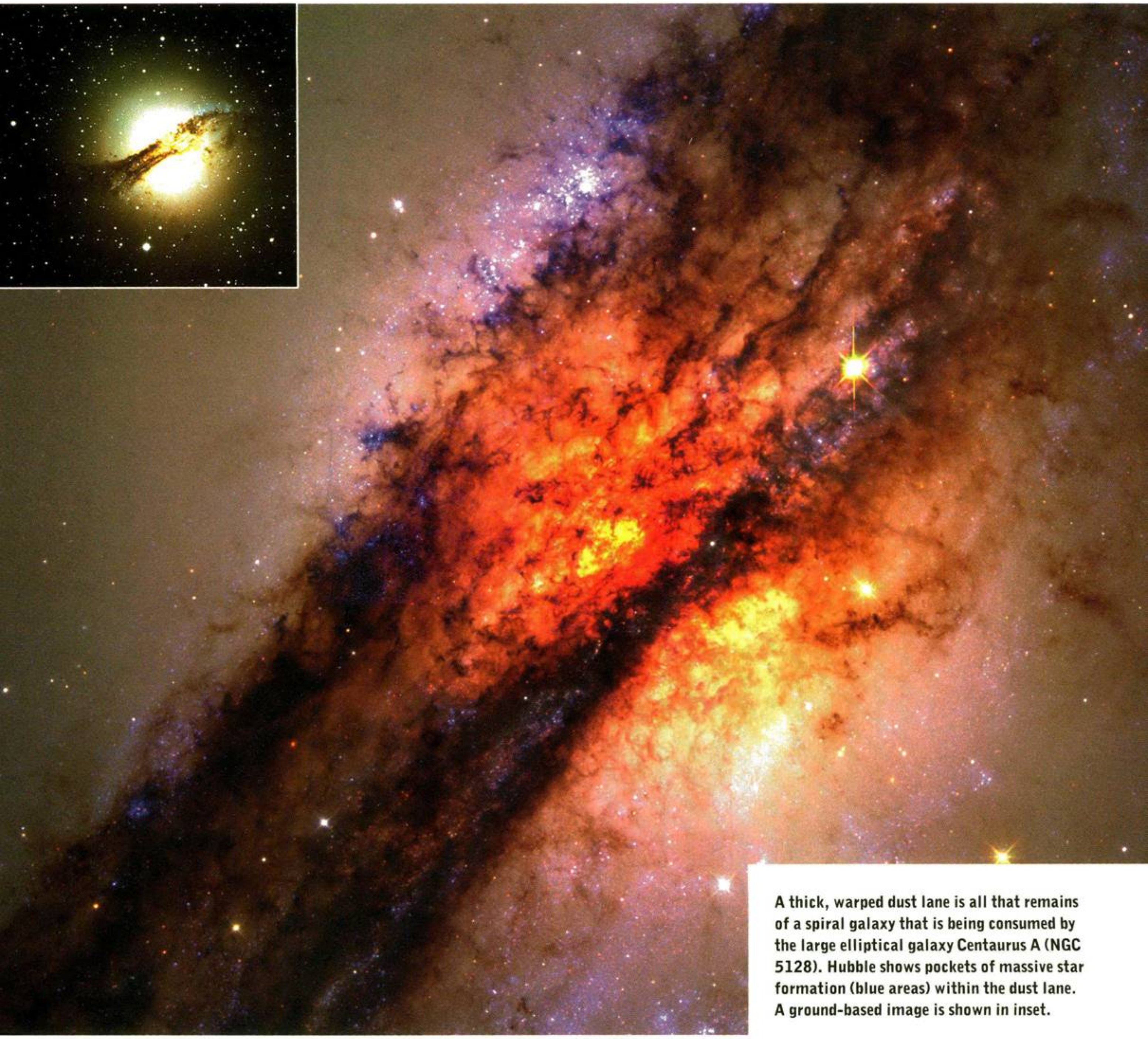
Raghvendra Sahai, John Trauger (JPL), et al., and NASA



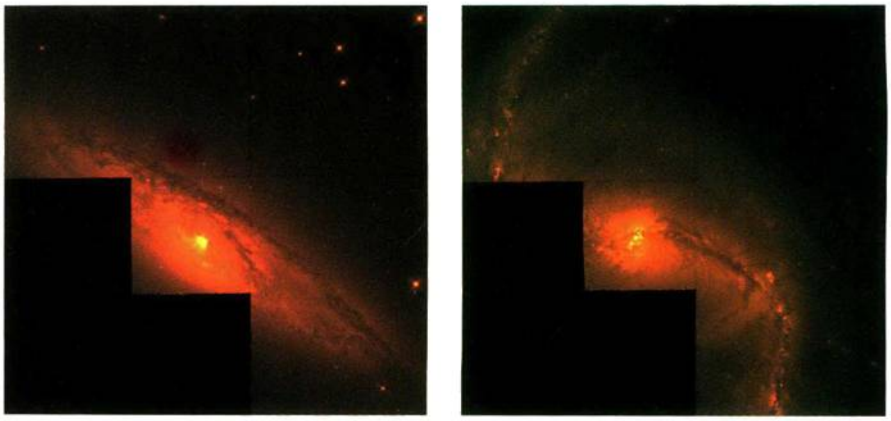
Kirk Borne (Raytheon STX Corp. and NASA/GSFC), and NASA



Henize 401, above, is a "bipolar" protoplanetary nebula en route to becoming a full-fledged planetary nebula. Astronomers are mystified by the origin of this extreme bipolar shape. Perhaps a disk of gas and dust around the dying central star is acting as a nozzle, allowing gas to flow away from the dying star in only two directions.

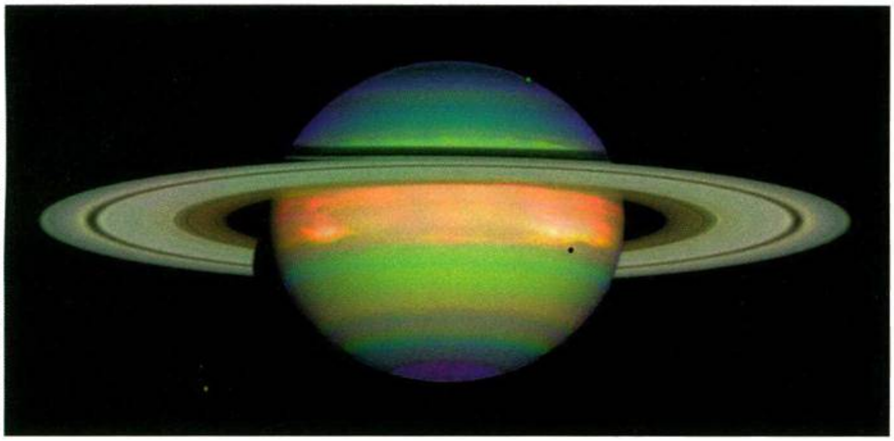


A thick, warped dust lane is all that remains of a spiral galaxy that is being consumed by the large elliptical galaxy Centaurus A (NGC 5128). Hubble shows pockets of massive star formation (blue areas) within the dust lane. A ground-based image is shown in inset.



These four spiral galaxies are part of a Hubble survey of 75 galaxies. Astronomers are studying how the properties of spiral galactic nuclei relate to the origin and structure of the galaxies' central bulges. From left to right, we see NGC 6810, NGC 986, NGC 5985, and NGC 4030.

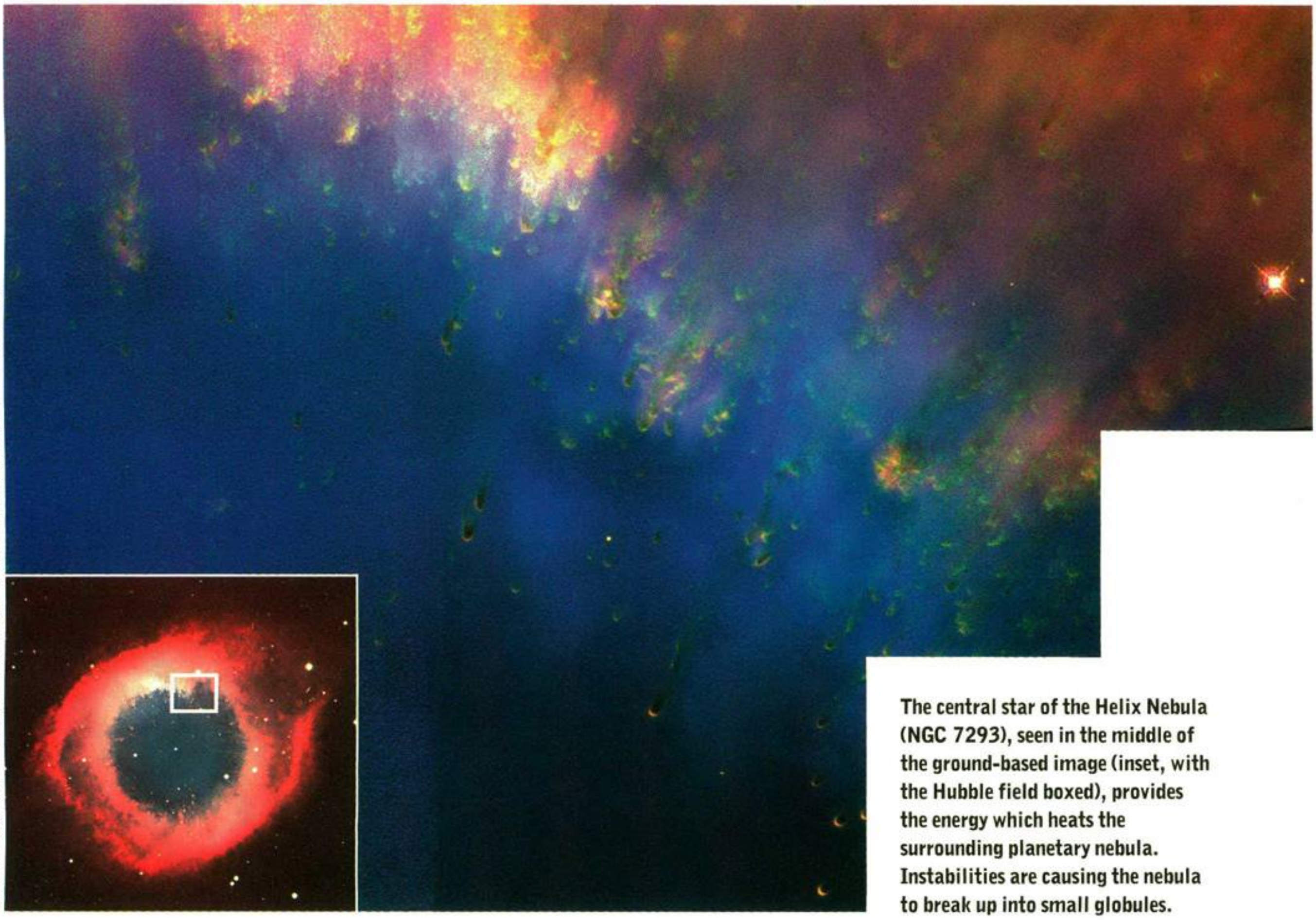
Erich Karkoschka (University of Arizona) and NASA



Hubble's NICMOS camera captures infrared sunlight reflected by Saturn's clouds and hazes. Blue indicates a clear atmosphere down to the main cloud layer, green and yellow represent haze layers above the main cloud deck, while red and orange are the highest clouds of all. Two Earth-sized storms swirl near the equator. The moons Dione (lower left) and Tethys (upper right, touching Saturn's limb) can also be seen.

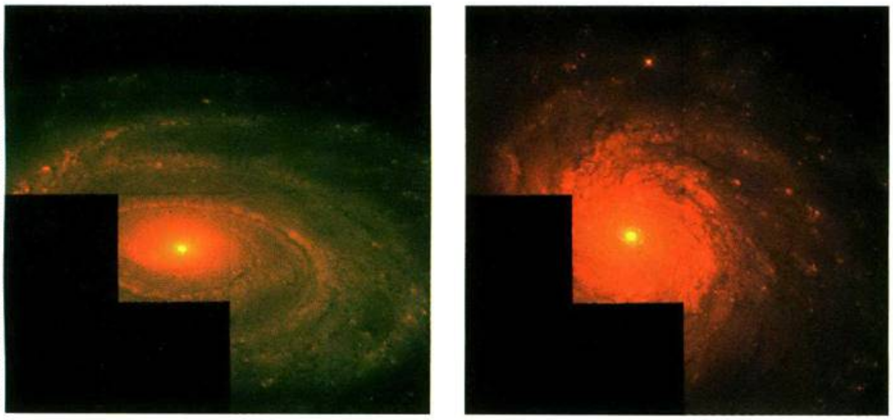
Ethan Schreier (STScI), et al., and NASA; Inset: Anglo-Australian Telescope Board/David Malin

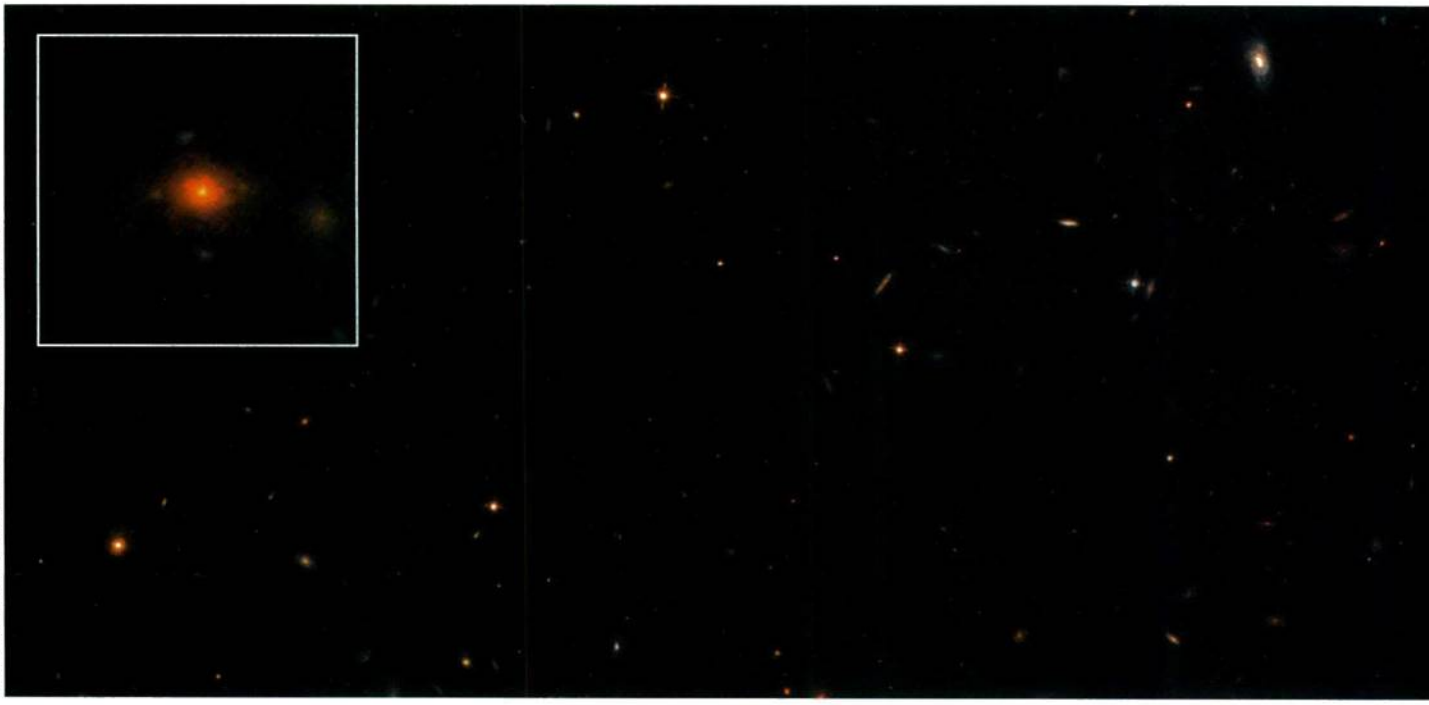
C. Robert O'Dell (Rice University), et al., and NASA; Inset: Anglo-Australian Telescope Board/David Malin



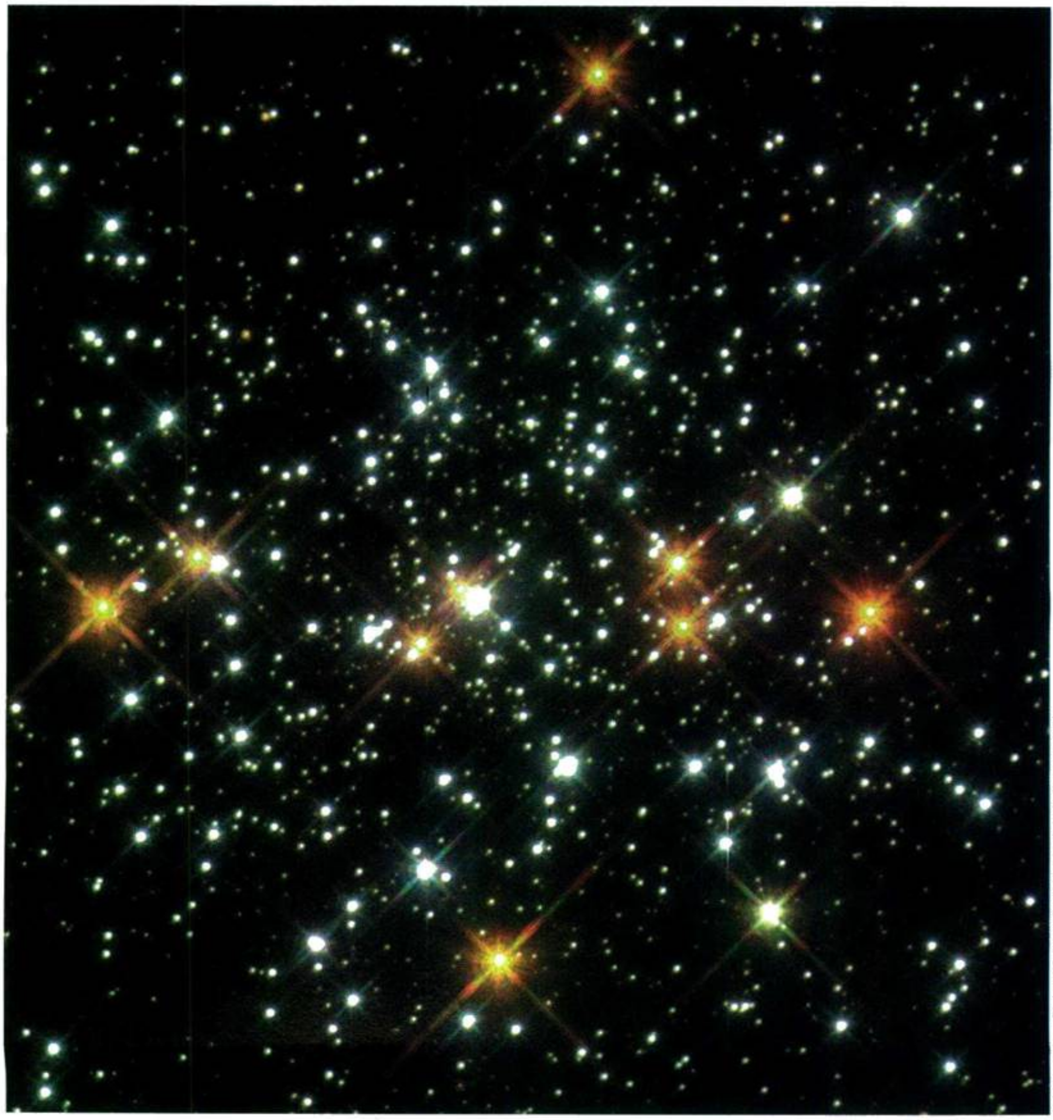
The central star of the Helix Nebula (NGC 7293), seen in the middle of the ground-based image (inset, with the Hubble field boxed), provides the energy which heats the surrounding planetary nebula. Instabilities are causing the nebula to break up into small globules.

Massimo Stiavelli (STScI), Marcella Carollo (JHU), and NASA



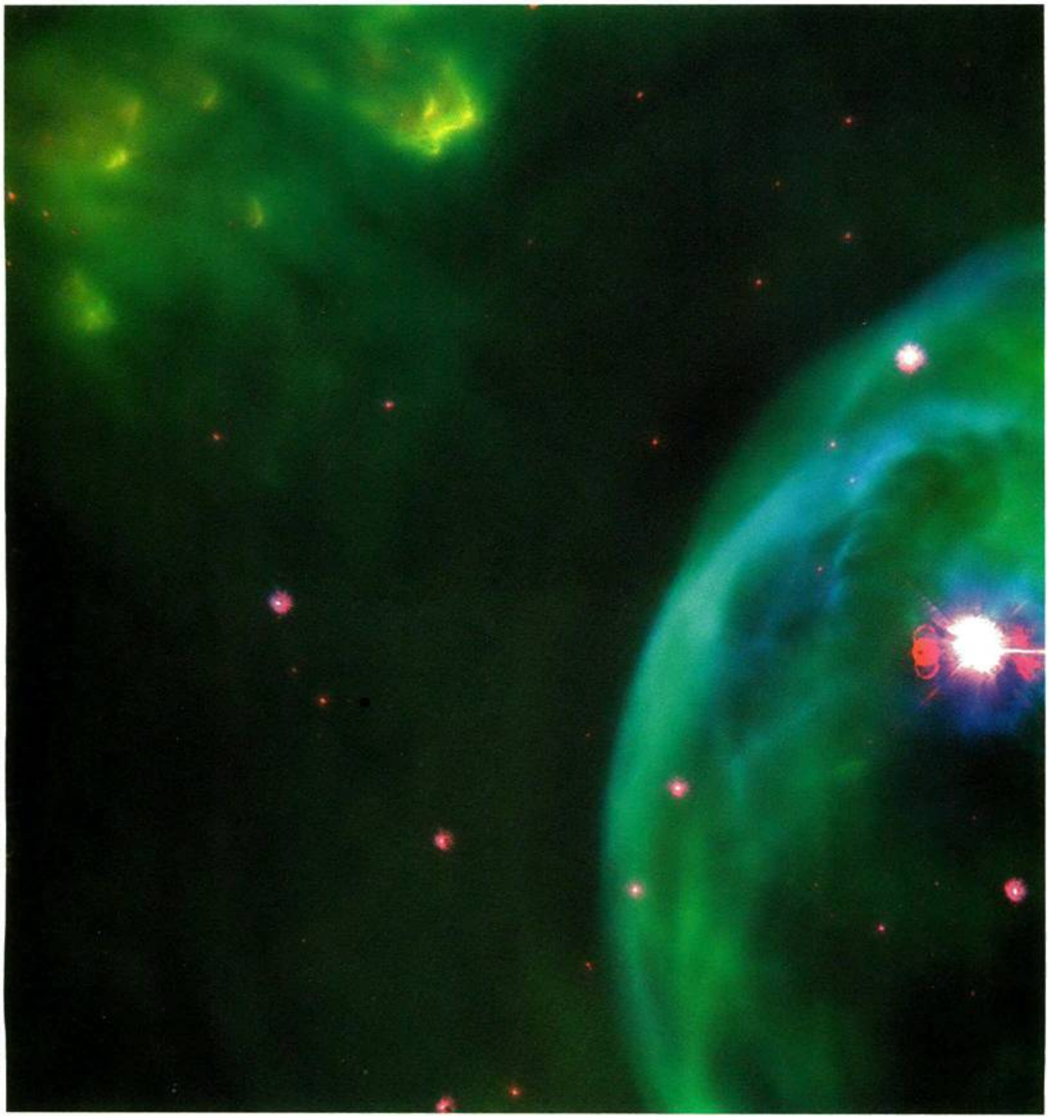


Edward Groth, Jason Rhodes (Princeton University), WFPC2 team, and NASA



Hubble resolves more than 20,000 stars in NGC 1818. This young star cluster is 164,000 light-years away in the Large Magellanic Cloud, the Milky Way's largest satellite galaxy. This image is a zoom-in on a larger image. The bright red stars are red giants and supergiants. This region is 140 light-years across.

Rebecca Elson, Richard Sword (Cambridge University), and NASA



Jeff Hester, Paul Scowen (Arizona State University), and NASA

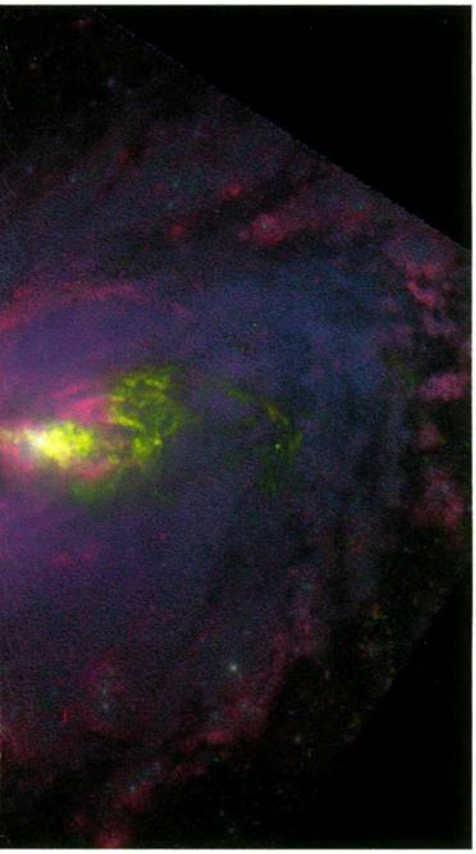
This image of NGC 7635 was taken before astronauts installed corrective optics for Hubble's flawed mirror. The bright star at the right is giving off powerful winds of gas and radiation, forming the curve-shaped bubble.

In January 1996 astronomers released the Hubble Deep Field, which showed the faintest galaxies ever seen at that time. But almost two years earlier, Edward Groth and Jason Rhodes of Princeton University took their own version of the Hubble Deep Field — the Groth Strip — just a small part of which is shown here.

The Groth Strip consists of 28 individual WFPC2 fields stitched into a mosaic that cover a stretch of sky in Ursa Major larger than a full moon. The image was taken over the course of 132 orbits and 68 hours. While the Groth Strip covers a field 28 times larger than the Hubble Deep Field, the Deep Field shows galaxies that are 15 times fainter than the faintest in most of the Groth Strip.

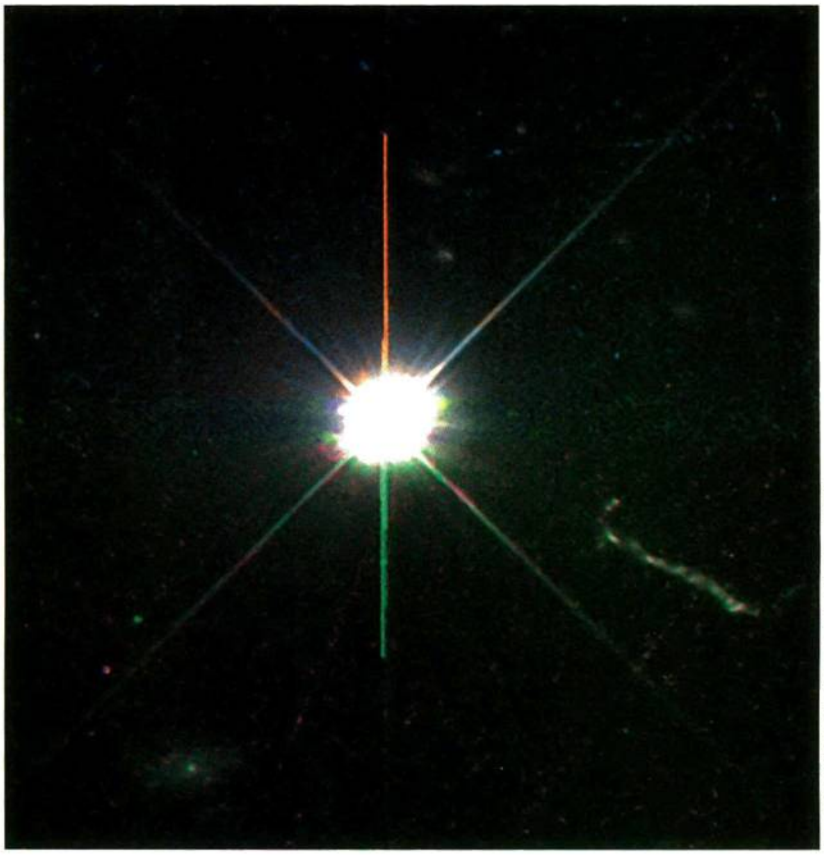
The brightest points of light (with diffraction spikes) are foreground Milky Way stars only a few thousand light-years away. In other places you can easily see spiral and elliptical galaxies hundreds of millions of light-years away. The faintest red and blue smudges are galaxies at least six billion light-years away. The field also contains a cross-shaped gravitational lens (inset). The entire strip shows between 10,000 and 20,000 galaxies.

Groth and Rhodes took the image to study how much galaxies clustered when the universe was half its current age. Even a casual glance reveals significant clustering.



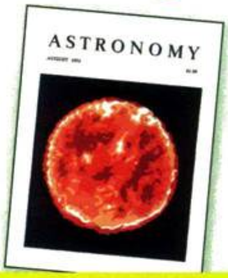
Cherie Miskey, Fred Bruhweiler (IACS/CUA and NASA/GSFC), and NASA

A supermassive black hole lurks in the center of M77 (NGC 1068), a large spiral galaxy some 50 million light-years away. This Hubble image shows gas and dust swirling around the black hole in a region of space about 8,000 light-years across. M77's nucleus shines with the intensity of 100 billion suns.



John Bahcall (Institute for Advanced Study), et al., and NASA

The powerful radio source 3C 273 was one of the first quasars discovered, back in 1963. Quasars stagger the imagination, cramming the energy output of an entire galaxy into a region of space the size of the solar system. Astronomers now believe quasars are the central regions of distant galaxies. Quasar engines are powered by supermassive black holes that feed on surrounding stars, gas, and dust. This Hubble image shows the clearest picture ever taken of a powerful jet (lower right) of subatomic particles shooting away from 3C 273 at nearly the speed of light. The jet was discovered 30 years ago by radio astronomers.



1973

Founder, publisher, and editor Stephen A. Walther pursues his dream of creating a popular astronomy magazine, organizing and incorporating AstroMedia Corp. in September 1972 and preparing the first issue by the spring of 1973.

AUG. First issue of *Astronomy* published; speckle interferogram of the star Betelgeuse graces the cover, which resembles *Scientific American* with its white border; consists of 48 pages.

OCT. Third issue features Mars article by Carl Sagan and preview of upcoming Comet Kohoutek appearance.

DEC. Pioneer 10 passes Jupiter.

Circulation: approximately 10,000

Best Picture: *The Sting*

Grammy Album Artist: Stevie Wonder, *Innervisions*

FEB. Mariner 10 passes Venus.

MAR. Mariner 10 arrives at Mercury.

APR. Hank Aaron hits 715th home run, surpassing Babe Ruth.

AUG. President Nixon resigns; Gerald Ford becomes 38th president.

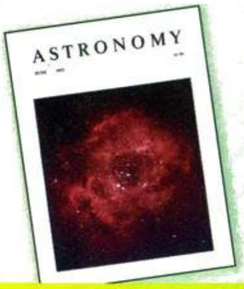
SEPT. Steve Walther named editorial director; Terence Dickinson becomes editor.

DEC. Pioneer 11 passes Jupiter.

Circulation: 23,593

Pulitzer: Daniel J. Boorstin, *The Americans*

1974



1975

JAN. The magazine swells to 80 pages; features articles by George Abell and William K. Hartmann.

APR. U.S. citizens and military evacuate Saigon, ending Vietnam War.

JULY Apollo 18 ends an era of exploration.

DEC. Circulation: 40,007

Best Picture: *One Flew Over the Cuckoo's Nest*

Grammy Album Artist: Paul Simon, *Still Crazy After All These Years*

JULY Viking 1 lands on Mars. Bicentennial of the United States.

AUG. Steve Walther diagnosed with a brain tumor after collapsing at a party.

SEPT. Viking 2 lands on Mars.

DEC. Circulation: 51,107

1976

FLEETWOOD MAC
RUMOURS

1986

JAN. The space shuttle Challenger explodes, killing its crew of seven. Voyager 2 encounters Uranus.

MAR. Comet Halley puts on its best show since 1910.

DEC. Circulation: 174,452

Best Picture: *Platoon*

Grammy Album Artist: Paul Simon, *Graceland*

Pulitzer: Walter A. McDougall, *The Heavens and the Earth*

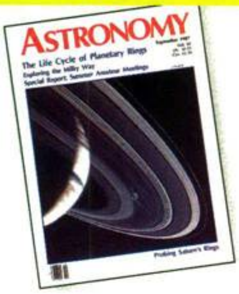
FEB. Supernova 1987A erupts in the Large Magellanic Cloud.

MAY U.S. Congress initiates Iran-Contra hearings. Iraqi missile hits USS *Stark* "by accident."

DEC. Circulation: 163,187

Grammy Album Artist: U2, *The Joshua Tree*

1987



1988

Drought besets U.S. farms.

JUNE Circulation: 164,967

JULY USS *Vincennes* accidentally shoots down an Iranian airliner.

DEC. Pan Am Boeing 747 explodes over Lockerbie, Scotland.

Best Picture: *Rain Man*

JAN. George Bush becomes 41st president.

MAR. *Exxon Valdez* spills 11 million gallons of oil off Alaska's coast.

AUG. Voyager 2 encounters Neptune. U.S. savings and loan industry fails; receives taxpayer bailout.

OCT. Earthquake rocks San Francisco area.

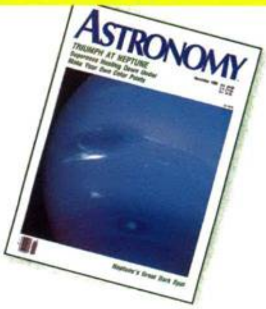
NOV. Cosmic Background Explorer satellite launched.

DEC. U.S. invades Panama.

Circulation: 160,664

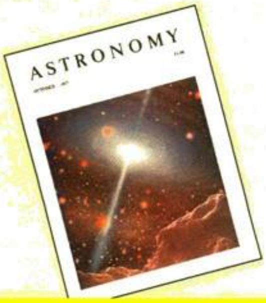
Pulitzer: Neil Sheehan, *A Bright Shining Lie*

1989



REMEMBER WHEN...

1977



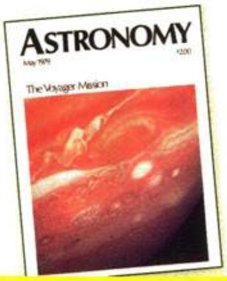
JAN. Jimmy Carter becomes 39th president.
MAR. Rings of Uranus discovered.
SEPT. On September 14, Steve Walther dies of a brain tumor, aged 33.
OCT. Reggie Jackson's three home runs lead New York Yankees to 21st World Championship.
DEC. Richard Berry becomes *Astronomy's* editor.
Circulation: 58,063
Grammy Album Artist: Fleetwood Mac, *Rumours*

1978

AstroMedia begins publishing *Telescope Making*, a quarterly, with Richard Berry as editor.
DEC. Pioneers arrive at Venus.
Circulation: 85,049
Grammy Album Artist: Bee Gees, *Saturday Night Fever*
Pulitzer: Carl Sagan, *The Dragons of Eden*

Saturday Night Fever

1979



MAR. Voyager 1 encounters Jupiter.
AstroMedia begins publishing *Odyssey*, a children's magazine of astronomy, with Nancy Mack as editor.
JULY Voyager 2 encounters Jupiter.
SEPT. Pioneer 11 passes Saturn.
NOV. Hostages taken at American embassy in Tehran, Iran.
DEC. Soviet Union invades Afghanistan.
Circulation: 97,773

1980

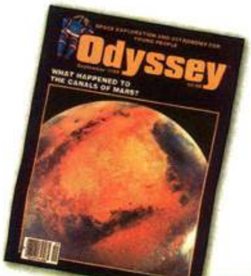
MAY Mt. St. Helens volcano erupts in Washington state.
NOV. Voyager 1 encounters Saturn.
DEC. John Lennon assassinated in New York City.
Circulation: 122,412
Pulitzer: Norman Mailer, *The Executioner's Song*

1981

ASTRONOMY
Charting the Infrared Universe

JAN. Ronald Reagan becomes 40th president.
MAR. Assassination attempt on Reagan.
APR. First space shuttle flight a success.
AUG. Voyager 2 encounters Saturn.
Circulation: 138,415
Best Picture: *Chariots of Fire*
Grammy Album Artist: John Lennon and Yoko Ono, *Double Fantasy*

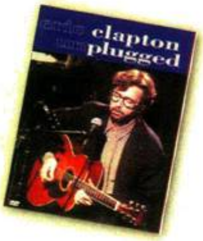
1990



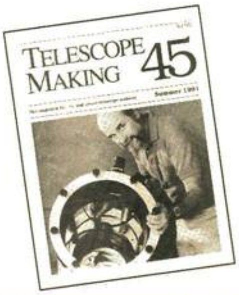
APR. Hubble Space Telescope launched into orbit.
AUG. Operation Desert Shield begins following Iraq's invasion of Kuwait.
SEPT. Magellan spacecraft begins mapping Venus.
DEC. Circulation: 157,949
Best Picture: *Dances with Wolves*

1991

JAN. Cosmic Background Explorer data help confirm big bang theory.
Gulf War erupts as United States and allies defeat Iraq.
Kalmbach sells *Odyssey* to Cobblestone Publishing Co.
APR. Compton Gamma Ray Observatory launched.
DEC. Soviet Union disbands and communism begins to unravel.
Circulation: 162,023
Best Picture: *The Silence of the Lambs*



1992



FEB. Kalmbach discontinues *Deep Sky* and *Telescope Making*.
APR. The Keck Telescope becomes the world's largest.
Riots in Los Angeles follow Rodney King verdict.
MAY Robert Burnham becomes *Astronomy's* editor.
SEPT. Mars Observer launches; communication lost 11 months later.
DEC. Circulation: 168,460
Grammy Album Artist: Eric Clapton, *Unplugged*

1993

JAN. Bill Clinton becomes 42nd president.
FEB. Bomb explodes in World Trade Center.
APR. Raid on Waco religious cult turns deadly.
JUNE Midwestern flood inundates nine states.
DEC. An ambitious spacewalk repairs the Hubble Space Telescope.
Circulation: 204,624
Best Picture: *Schindler's List*

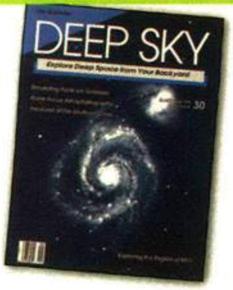
ASTRONOMY
FORECAST: 21st CENTURY
ASTRONOMERS PREDICT DISCOVERIES
New Voyages of DISCOVERY

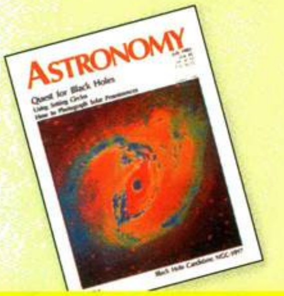
1994

JAN. Earthquake rocks Los Angeles.
MAR. Wayne Gretzky scores his 802nd goal, surpassing Gordie Howe.
MAY Annular eclipse of the sun washes over the United States.
JULY Comet Shoemaker-Levy 9 slams into Jupiter.
AUG. Strike halts major league baseball.
DEC. Circulation: 171,301
Best Picture: *Forrest Gump*

SEPT. *Astronomy* buys *Deep Sky Monthly* magazine, retitles it *Deep Sky*, and publishes it as a quarterly, hiring Dave Eicher as editor.
DEC. Circulation: 188,308

1982



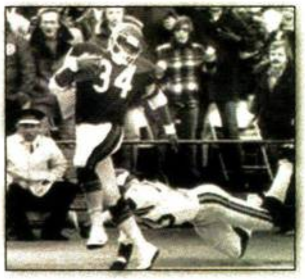


1983

JUNE Pioneer 10 leaves solar system. Sally Ride becomes the first U.S. woman in space.
SEPT. Soviet Union shoots down Korean Airline Flight 007.
OCT. The United States invades Grenada.
U.S. soldiers bombed in Lebanon.
DEC. Circulation: 145,581
Grammy Album Artist: Michael Jackson, *Thriller*

APR. Kareem Abdul-Jabbar scores 31,420th point, breaking Wilt Chamberlain's record.
OCT. Walter Payton rushes for his 12,313th yard, surpassing Jim Brown.
DEC. Circulation: 131,839
Grammy Album Artist: Lionel Richie, *Can't Slow Down*

1984

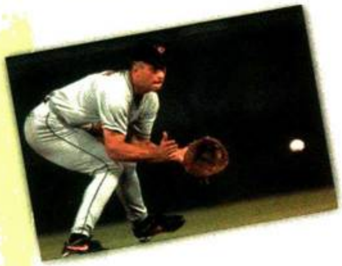


1985

Kalmbach Publishing Co. buys AstroMedia Corp. and begins publishing *Astronomy*, *Odyssey*, *Telescope Making*, and *Deep Sky*.
JULY "Live Aid" concert benefits starving children in Africa.
SEPT. Pete Rose gets hit number 4,192, breaking Ty Cobb's record.
DEC. Circulation: 157,771
Pulitzer: Studs Terkel, *The Good War*

JAN. *Astronomy* launches its first annual issue, *Observer's Guide 1995*, which sells 69,975 copies.
In Los Angeles, the O. J. Simpson murder trial gets under way.
APR. Bomb rips through Oklahoma City Federal building.
SEPT. Cal Ripken, Jr. plays in his 2,131st consecutive game, breaking Lou Gehrig's record.
DEC. Galileo spacecraft arrives at Jupiter.
Circulation: 159,957
Pulitzer: Doris Kearns Goodwin, *No Ordinary Time*

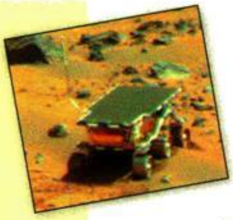
1995



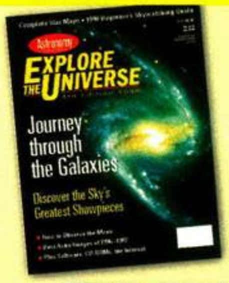
1996

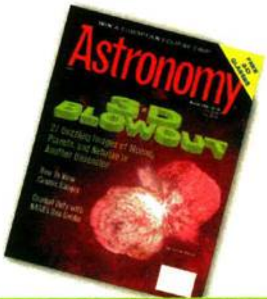
JAN. Extrasolar planets discovered in Ursa Major and Virgo.
Observer's Guide 1996 sells 64,288 copies.
MAR. Comet Hyakutake thrills observers with its long tail.
JULY TWA Flight 800 explodes off the New York coast.
AUG. Scientists announce possible microfossils in martian rock.
NOV. Bonnie Bilyeu Gordon becomes *Astronomy's* editor.
DEC. Carl Sagan dies.
Circulation: 171,226
Best Picture: *The English Patient*

JAN. *Astronomy's* annual *Explore the Universe 1997* sells 78,008 copies.
Clyde Tombaugh, discoverer of Pluto, dies.
MAR. Comet Hale-Bopp dominates the sky.
JULY *Astronomy* redesigned; adopts a full-bleed cover.
Mars Pathfinder arrives on and explores the Red Planet.
AUG. Princess Diana killed in Paris car crash.
OCT. Cassini launches toward Saturn.
DEC. Circulation: 181,959
Best Picture: *Titanic*



1997



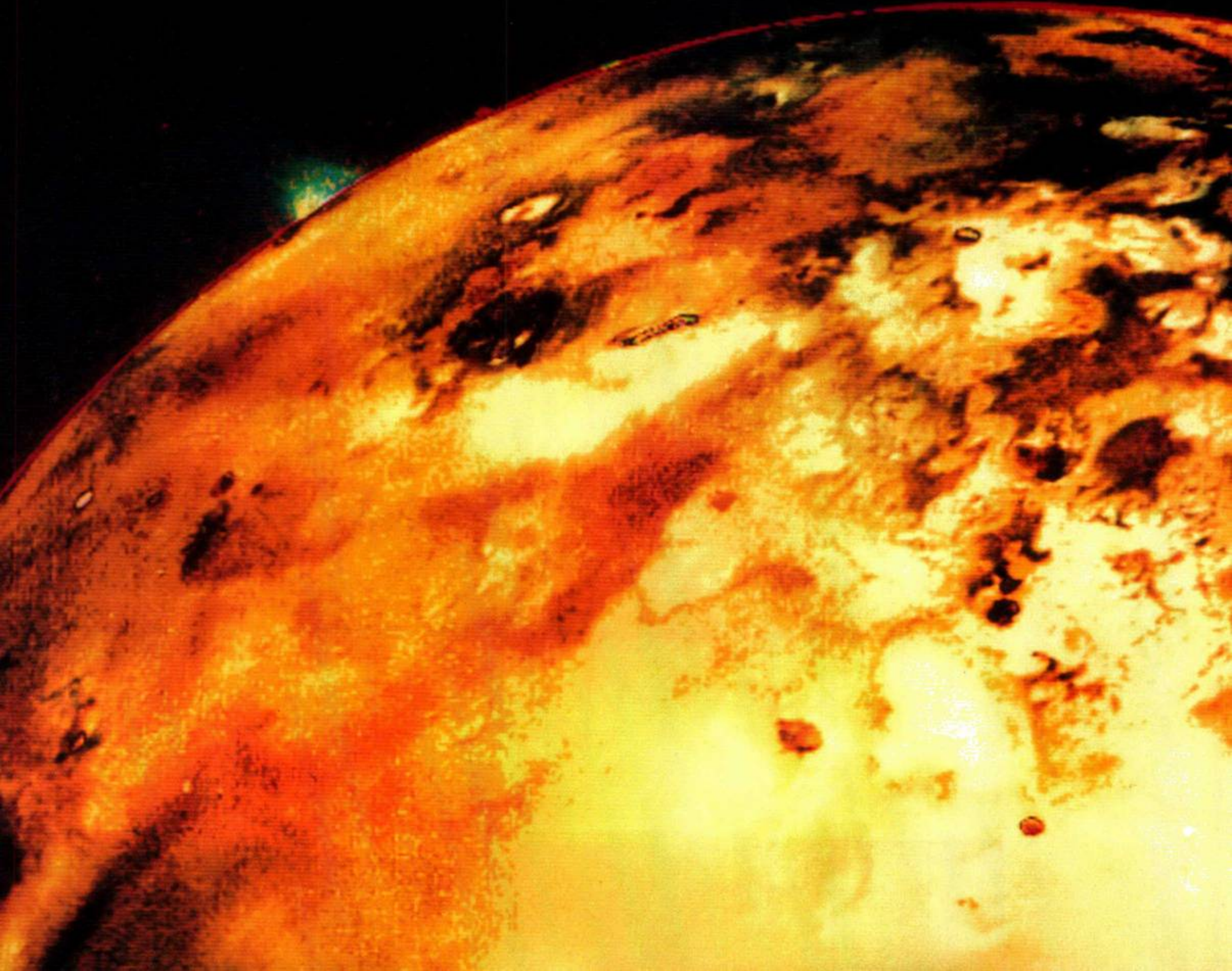


1998

JAN. *Explore the Universe 1998* sells 83,581 copies.
Astronomy sponsors a science forum at American Astronomical Society meeting.
FEB. The magazine sponsors a Caribbean cruise to see the total solar eclipse.
MAR. Our first 3-D issue features inserted glasses.
Circulation: 209,179
JUNE *Astronomy* sponsors star party near Albuquerque.
AUG. *Astronomy's* 25th Anniversary Issue hits the newsstands.

the Great Solar System

The past 25 years



have changed our view of the solar system forever.

Revision

by William K. Hartmann

THE FIRST 25 YEARS OF *ASTRONOMY* MAGAZINE COINCIDED WITH A UNIQUE QUARTER-CENTURY IN THE HISTORY OF HUMANITY: IN THAT PERIOD, OUR SYSTEM OF PLANETS WENT FROM UNKNOWN TO KNOWN. EVERY FIELD OF ASTRONOMY MADE ASTONISHING PROGRESS, BUT PLANETARY EXPLORATION EXPERIENCED THE MOST PROFOUND REVOLUTION OF ALL.

This is a strong statement, but a few moments of reflection help us see how true it is. Other fields of astronomy exhibited a continuous stream of progress throughout the whole century. Astronomers began to understand stellar evolution, stellar and galactic distances, and the Big Bang — all in the first two-thirds of the century. The last 25 years have significantly added to those areas of knowledge, but objects outside the solar system remained *astronomical* objects.

Within the solar system, however, many objects have been transformed in less than a generation from purely astronomical objects to geological *places*. Since 1973, we have become the first generation to map the surfaces of planets and moons. We landed on Venus and Mars and began to understand planetary atmospheres and rock mineralogies. We also became the first to see asteroids and a comet close up, the first to see the rings of Jupiter, Uranus, and Neptune, and the first to examine Saturn's rings in detail. Ours will be the only generation in history to make these discoveries for the first time.

Variety Is the Spice of Life

When *Astronomy* was born in 1973, the Apollo moon landings had just ended, earlier than originally planned. Humanity's space exploration goals shifted to the planets.

How rudimentary our knowledge of planets, moons, asteroids, and comets was at that time! We had no surface photos from any planets, and only Venus and Mars had been imaged from close range. We were still uncertain about surface conditions on Mars (some scientists thought we might find primitive plant life there). Only Saturn had rings.

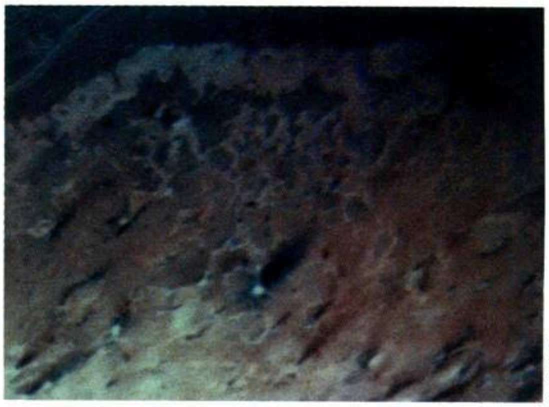
Scientists were stunned by Voyager 1's 1979 discovery of frenetic volcanic activity on Jupiter's large moon Io.
NASA/JPL

Dozens of small moons remained to be discovered. Pluto was the only known body of its type.

Most planets were virtual blank slates. Visual observers published sketches of vague shady markings on Mercury, but the sketches did not agree very well. The best telescopes showed the four big moons of Jupiter as fuzzy pinheads. The situation was even worse for the other giant planet satellites. Except for Saturn's moon Titan, which was known to have an atmosphere containing methane gas, the moons were assumed to be uniformly bland, cratered iceballs. Because these moons were cold and small, it was confidently felt that they would all be geologically dead.

The situation began to improve in 1975 when the Soviet Venera 9 probe returned the first surface photos from Venus. Data from Venera 9 and subsequent Veneras showed that Venus's surface seemed to be covered by basaltic volcanic lavas. Similarly, the two American Viking landers returned the first surface photos of Mars in 1976. Instead of primitive organisms, only sterile surface soil was detected at both sites (although the possibility remains that microbial martians eke out an existence underground). Chemical analysis indicated a generally basaltic composition for the martian soils too, a result supported by the Mars Pathfinder lander in 1997.

Comparing these results to Earth, scientists noted that although the continents are granitic rock (more silicate-rich than basalts), basaltic lavas are the main constituent of Earth's crust, especially sea-floor crust. The spacecraft results thus led to a new appreciation that basaltic volcanism is the leading internal shaper of planetary surfaces in the inner solar system, paralleling the finding that impact cratering is the leading external shaper.

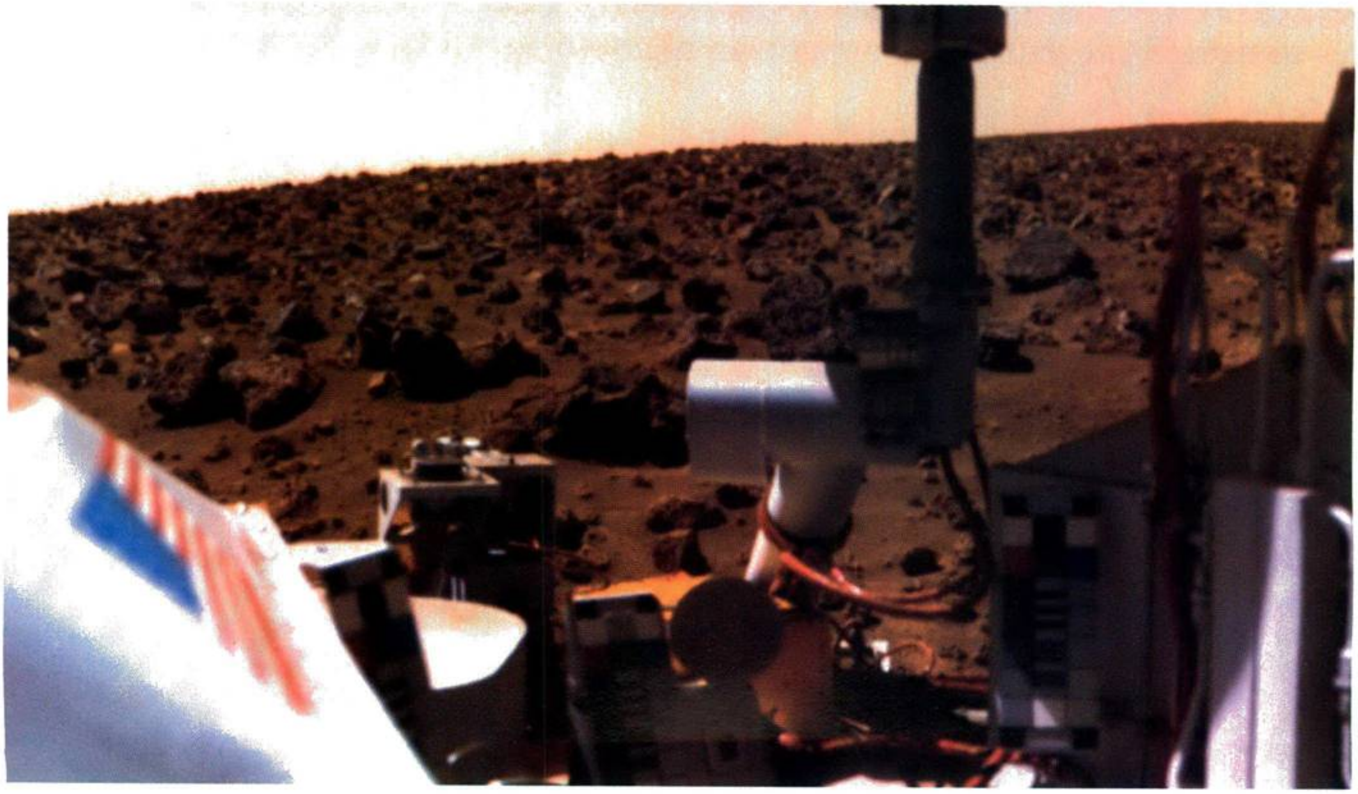

NASA/JPL

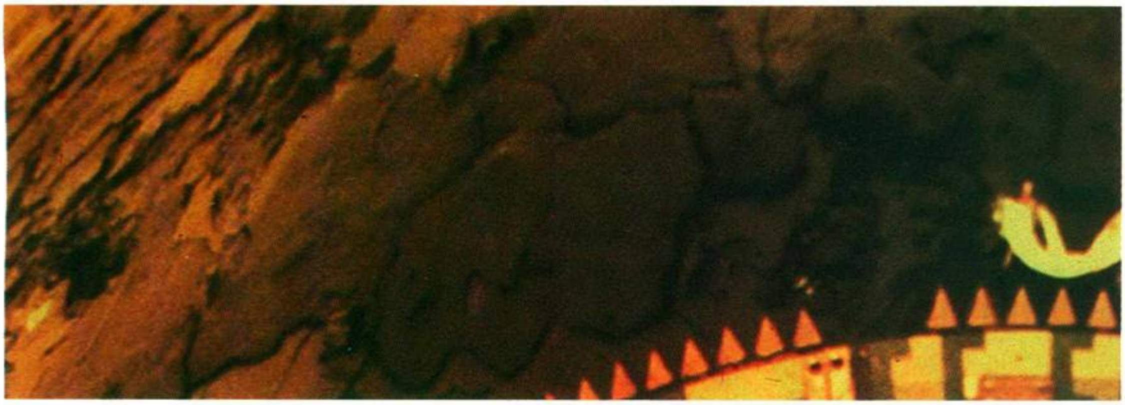
Neptune's satellite Triton has active geyser-like vents that shoot columns of smoke into its thin air — giving rise to the black streaks seen in this Voyager 2 image.

Probably the most dramatic changes in our perceptions of the solar system came when the two Voyager probes reached Jupiter in 1979. Instead of the expected indistinguishable dead iceballs, the Voyagers astounded everyone by showing that the four large moons had distinct personalities. Callisto had an old, cratered surface, as expected. Ganymede also had old, cratered regions, but they were broken by swaths of bright, fractured ice. Europa turned out to have a very young crust of fractured ice, apparently overlying an ocean of liquid water that could conceivably support life.

Io was the biggest surprise, with nearly a dozen

In 1976, a dream became reality when NASA's twin Viking landers returned pictures from the ruddy, sandy plains of Mars.


NASA/JPL



Sovfoto

In the 1970s and 80s, four Soviet Venera landers photographed the surface of Venus for about an hour each before succumbing to the hellish atmospheric conditions.

actively erupting volcanoes and a colorful surface of sulfur compounds. Just days before Voyager 1 arrived and discovered Io's volcanoes, California geophysicists Stanton Peale, Patrick Cassen, and Ray Reynolds predicted in *Science* there might be volcanic activity on Io. Peale and colleagues examined how tidal forces arising from the gravitational influence of Jupiter and the nearby satellites would flex Io, heating the moon's interior and leading to active volcanism. The power of science lies in its predictive ability; no other system of human thought, from classical philosophy to occult mysticism, could have predicted this.

Even after the revelations at Jupiter, most scientists still thought that dormant iceballs would prevail among the smaller and colder satellites of the more distant planets. But Voyager photos from 1981 to 1989 revealed that several of Saturn's icy moons have swaths of fractures, Uranus's moon Miranda has a surface completely twisted and deformed by systems of fractures and faults, and, most surprising of all, Neptune's moon Triton has volcanic vents that lift columns of black smoke high into its thin atmosphere. These discoveries suggest that tidal heating is even more important than had been thought. The bottom line? There is much greater variety among the moons and planets than we had anticipated.

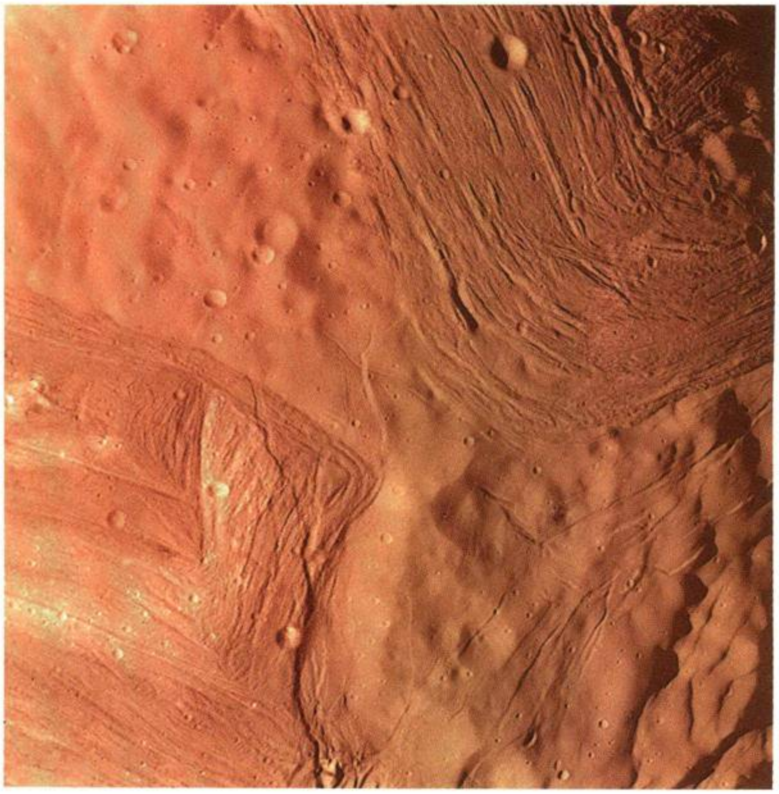
Two Sides of the Same Coin

In 1973, our understanding of asteroids and comets was, in some ways, even more Neolithic than our understanding of planets and moons. Asteroids and comets were treated as two unrelated phenomena. In telescopes, asteroids looked like stars (hence the name *aster*-oid). Comets looked fuzzy and gave off gas that must have come from ices. Comets thus came to be studied by astronomers trained in gas spectroscopy, and virtually nobody talked about the surface or geologic properties of a solid comet itself. If you went to a planetary science meeting, you would find asteroids discussed in one session by scientists interested in rocks and minerals and comets discussed in another session by scientists interested in gas spectra, dust emission, and tail structure.

On closer inspection, asteroids and comets turned out to be two sides of the same coin. The seeds of the new view were sown in the mid-1970s, when researchers such as Tom McCord, Clark Chapman, and David Tholen began to show that asteroids were dramatically divided into groups based on color, reflectivity, and spectral properties. In 1977, Charles Kowal discovered a 500-mile-wide (300 km) "asteroid" between Saturn and Uranus named Chiron. As with other outer solar system asteroids, it was black. But in 1988, it turned into a comet, brightening and sprouting gas and a cloud of dust. Reverse cases were also observed, in which objects initially cataloged as comets had become indistinguishable from asteroids.

Astronomers were also finding that comet nuclei were not the dirt-speckled white icebergs

Uranus's small moon Miranda is wracked with fractures and faults, possibly a result of a giant impact that tore the moon asunder.



NASA/JPL

that had been visualized, but black objects whose colors matched those of asteroids in the outer solar system. In 1986, a consortium of European countries flew the Giotto probe close enough to Comet Halley to show its potato-shaped structure and jets of gas streaming from discrete vents on the surface. Comets at last were thought about as solid worldlets.

The seeming distinction between these classes broke down. Instead of thinking of two distinct classes, it's more helpful to think of the original ancient planetesimals that aggregated into the planets. The ones closer to the sun were rocky, and contained metal, which in some cases sank to the center to make iron-nickel cores. The ones farther from the sun were dominated by lower temperature materials, ices, and black, carbonaceous material. When these icy bodies pass close enough to the sun, the ice sublimes into gas, creating a head and tail of gas and dust. But when they are far from the sun and inactive, they look merely like black asteroids.

In the 1990s, spacecraft passed close enough to three asteroids to photograph them. As expected, they turned out to be cratered, potato-shaped objects. One out of the three, Ida, has a tiny satellite of its own, confirming earlier speculations that some asteroids might have satellites. The 1997 NEAR flyby of Mathilde showed an asteroid with a surprisingly low density, indicating that many asteroids' internal structures were highly fractured by collisions.

Also in the 1990s, Jane Luu, David Jewitt, Anita Cochran, and others mapped out two new populations in the outer solar system. Chiron turned out to be just the first of a number of bodies that cross among the orbits of the giant planets. They were named Centaurs, after the half human, half horse beasts of Greek mythology. Beyond the Centaurs, a larger reservoir of objects exists in the general realm of Pluto and beyond. These comprise the Kuiper belt, named after Dutch-American astronomer Gerard Kuiper, who speculated about its possible existence a generation ago. There is a pattern here: Just as Earth-approaching asteroids are a small group that "leak" into the inner solar system from the asteroid belt, the Centaurs are a small group that leak into the giant planet region from the Kuiper belt.

En route to Jupiter, Galileo discovered that the 35-mile-long asteroid Ida has a one-mile-wide satellite, later named Dactyl.

NASA/JPL

ESA

Giotto imaged potato-shaped Comet Halley in 1986 — humanity's first close-up look at a comet nucleus.

When Pluto was discovered in 1930 there was little hesitation in celebrating it as a new planet. Today, however, Pluto seems more properly classified as merely the biggest known object in the Kuiper belt. Pluto is smaller than our own moon, its orbit is more eccentric and inclined than any other planetary orbit, and its path crosses Neptune's. Some have argued that Pluto's relatively large satellite Charon elevates it to planet status, yet now we know that some asteroids have satellites. In the new view, Pluto is to the Kuiper belt as Ceres is to the asteroid belt (Ceres being about twice as large as the next biggest asteroid).

Chaos and Catastrophe

The discovery of these different populations of small objects has in turn led to the growing awareness that planetary rotational and orbital properties involve a mixture between many small collisions (which produce regularity, circular orbits, and uniform properties), and rare, large-scale collisions or near-misses (which produce irregularity, non-circular orbits, and distinctive properties).

In the 1960s, Soviet researchers, especially Victor Safronov, were at the forefront of showing how planetesimals collided and aggregated into planets. Safronov suggested that the aggregation of countless small bodies would tend to give planets fairly uniform properties, such as west-to-east spin directions, but that a few large collisions had left a few planetesimals with distinctive "personalities." Safronov suggested, for example, that a large impact had given Uranus its peculiar sideways axial tilt.

In 1974-5, Donald R. Davis and I extended Safronov's ideas by suggesting that the moon formed when a giant impact blasted mantle material out of Earth. This would explain the resemblance between chemical properties of the moon and Earth's mantle. We showed that bodies big enough to do the job could have grown in Earth's zone as Earth grew. Still, this scenario was considered too catastrophic to satisfy most scientists in the 1970s, who felt that planet-shaping processes had to be slow and gradual. The giant impact theory of lunar origin was not accepted as the leading explanation until 1984.

Also in the early 1980s, compelling evidence emerged that the dinosaurs were wiped out by the impact of a six-mile-wide (10 km) asteroid 65 million years ago. Further studies suggested that other changes in the biological and geological records were also linked to impacts. The idea of random cosmic impact disasters as a major agent of biological change was a radical departure from classic Darwinism, in which biological change was forced by mutation and competition *within* Earth's ecosystem. Philosophically, then, this quarter-century has seen a shift from gradualism to a view that while planetary evolution is generally gradual, it is also affected by catastrophic cosmic accidents.

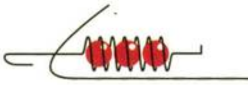
The realization of the significant role of random impacts has also led to a wide interest in "chaos theory." The orbits of small bodies, like Chiron, can evolve chaotically. This means that dynamicists can't calculate their orbits forward or backward for long stretches of time, because these bodies experience close approaches with planets. In these encounters, tiny shifts in position can lead to whopping changes millions of years later. The long-term future of the solar system is not as predictable as we thought it was 25 years ago.

All these issues lead to questions about the origin and long term history of planetary systems. Did other planetary systems form like ours? How common are circular, stable orbits where a planet can stay in a liquid-water zone all year? How common are planetary systems where liquid water exists and where life can form and survive? How common are Earthlike planets throughout the universe?

The Universe Beyond

In the 1990s planetary science has made the giant leap out of the solar system with the discoveries of planet-sized bodies orbiting other stars. Our planetary system is not a unique accident in the universe. In the next 25 years, we will see increasing emphasis on comparisons between our own solar system and other planetary systems. In fact, a new question has replaced the old one: Is it possible that our system has had a unique history that produced circular, stable planetary orbits?

Theorists had confidently predicted that planetary systems would display circular orbits with Jupiter-sized giants at large distances. Yet it seems clear that other systems don't always follow these rules. Many of the newly-discovered planets have elliptical orbits and most of these Jupiter-sized planets lie very close to their host stars. These findings have led to reexamination of orbit evolution. A new idea, discussed by dynamicist Stu Weidenschilling and others, is that two, three, or more Jupiter-sized bodies may have aggregated in the same region. Instead of the largest one outpacing the growth of the others and sweeping them up, the second and third largest might have become very big in some cases and then experienced close encounters that might have thrown them into elliptical orbits. In such an encounter, one giant planet might have been left at, say five AU, a second would have been thrown into an orbit very near the star, and a third planet would be ejected from its system altogether.

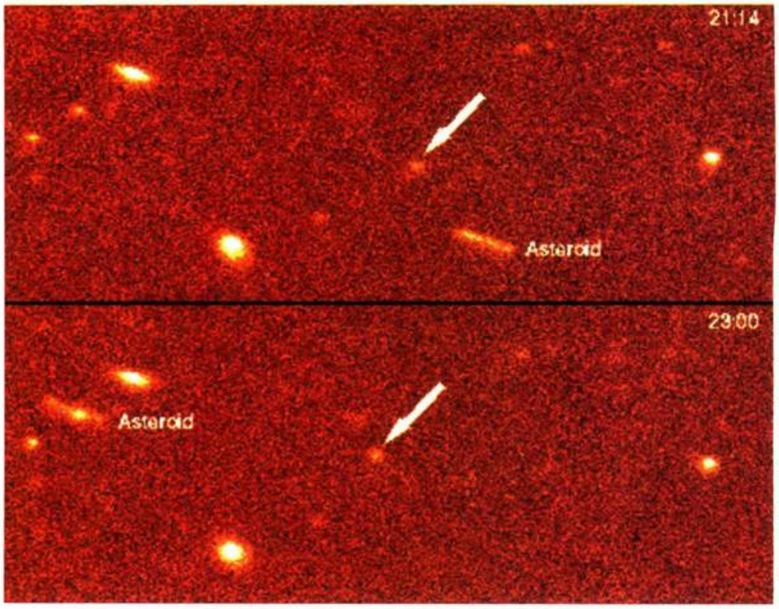


These questions remind us that planetary science, perhaps more than any other field of astronomy, is really about us and our own role in the universe. The question of microbial life on Mars or in the seas of Europa, the rate of species-threatening impacts on planets, and the quest for planetary systems around other stars: All these topics reflect back to questions about whether we are unique in the universe.

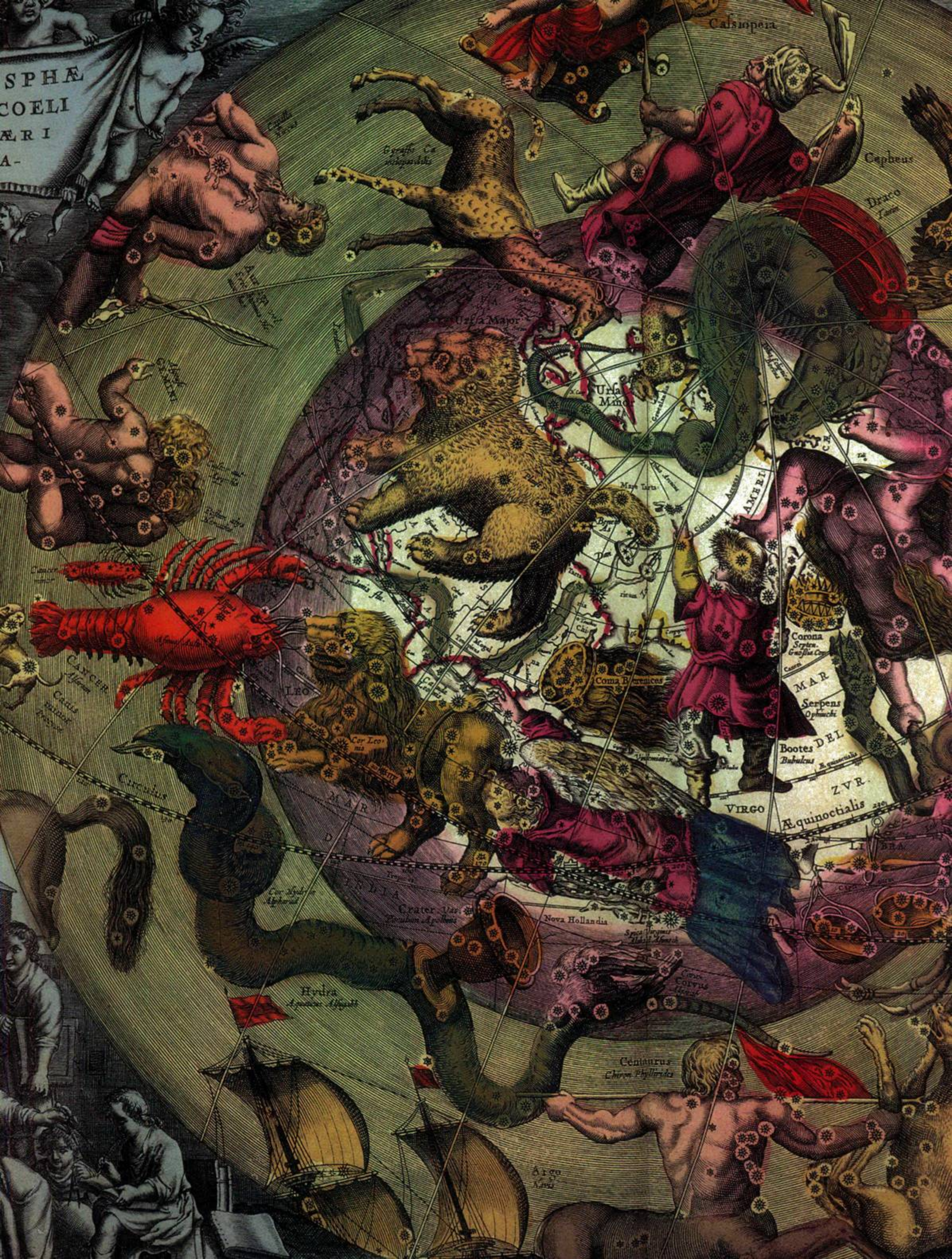
If you were born on an island and saw other islands on the horizon, you would yearn to go there and find out how they compared to your own. In the first 25 years of *Astronomy,* the first voyages have been taken to the nearby islands, and the blank maps of other worlds have begun to be filled in.

Planetary scientist William K. Hartmann recently published the novel Mars Underground *and was awarded the first Carl Sagan Medal by the American Astronomical Society, for communication of planetary science to the public. His articles and artwork have appeared in* Astronomy *almost since its inception.*

The discovery of 1992 QB$_1$ opened the door to a new frontier beyond Pluto, the Kuiper belt.



David Jewitt (Univ. of Hawaii) and Jane Luu (Harvard Univ.)


SPHÆ
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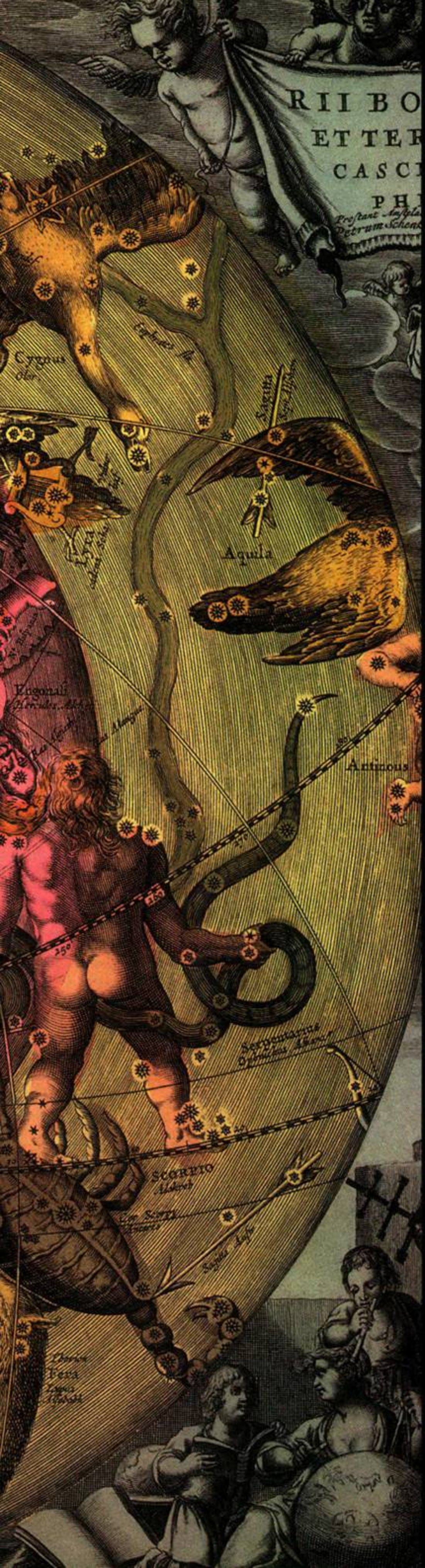
Draco
Ursa Major
Ursa Minor
AMERI
Corona Septen.
Serpens Ophiuchi
MAR
DEL
Bootes Bubulcus
ZVR.
Æquinoctialis
VIRGO
LIBRA
Coma Berenices
Cor Leonis
LEO
CANCER
Circulus
MAR
INDIA
Crater
Nova Hollandia
Corvus
Hydra
Centaurus
Chiron Phyllirida
Argo
Navis



ASTRONOMY'S

Essay Contest

SILVER

Winners

ANNIVERSARY

The compositions submitted to our silver anniversary essay contest arrived as a spring blizzard of postal envelopes, e-mails, and air-freight packages from all 50 states, every continent, and a sprinkling of island nations. The contest announced months earlier had set off a literary El Niño. The essay authors included poets and a psalmist, at least one high school student, and several with PhDs. A Titusville, Florida, man used a typewriter whose ribbon was running dangerously low on ink. Several priests submitted essays as did a prison inmate who used a pen and paper.

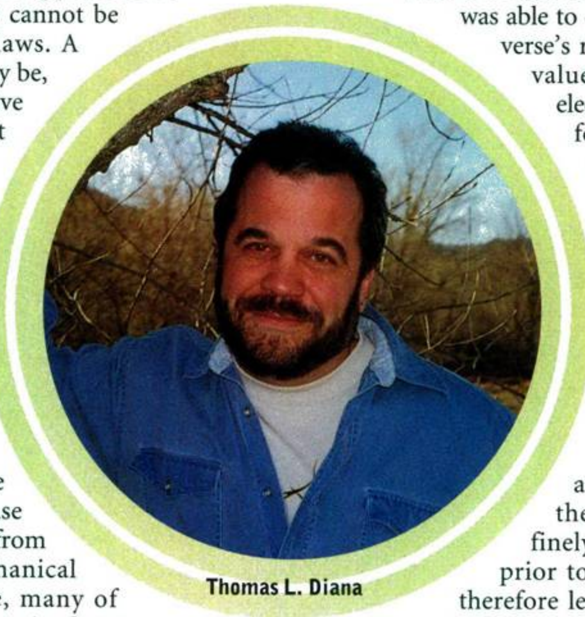
Regardless of the software or hardware used, and irrespective of the delivery method employed, the editors of *Astronomy* were stunned by the sum of the authors' knowledge and creative energy. We thank them.

Identifying three winners amid the avalanche of 8½-by-11-inch paper was excruciating — and arbitrary in the end. Each of the following three winners exhibit rhetorical elegance and a refreshing, personal voice. They are a pleasure to read and ponder. We hope you like them as much as we do.

Ursa Minor
Coma Berenices
Nova Hollandia
Corvus
Centaurus

Can one believe simultaneously in God and the Big Bang?

by Thomas L. Diana


Thomas L. Diana

Humans have maintained belief in a Creator ever since being able to ask the question, "Where did we come from?" As our knowledge of the physical sciences has increased, however, the need to resort to God as a causal agent has steadily decreased. There appears to be little in cosmology that cannot be explained by natural laws. A more likely question may be, "How can one still believe in God given our present understanding of the cosmos?"

Early civilizations believed that many gods inhabited the Earth and heavens. Each was responsible for managing his or her specific realm. They had a direct and immediate effect on our lives. At best, we could attempt to appease them. After we moved from an animistic to a mechanical model of the universe, many of these spirits were exorcised. We no longer needed supernatural explanations for natural phenomena.

Humans long believed that the Earth was seated at the center of the universe. Everything revolved around us. Although the Copernican revolution eventually shifted us from a geocentric to a heliocentric model of the universe, our world maintained a relatively central location in a fairly small domain. It was only during this century that certain "nebulae" were discovered to be galaxies like our own, receding from us at tremendous rates of speed. As the big bang model gained greater acceptance, we found ourselves further displaced from our privileged position in the cosmos. We have been reduced to infinitesimal beings in a vast, expanding universe to which there is no center.

Many theologians saw no problem with the big bang theory. It mattered little if the universe began as a singularity of fundamental particles. Our primordial soup still needed a chef. God's throne simply needed to be relocated. However, quantum mechanics has seriously challenged the necessity of a Prime Mover. Quantum fluctuation allows for the possibility of particles emerging out of a vacuum. God was not even needed to create the conditions prior to the Big Bang. Besides, it seemed absurd to speak of a Being before being.

One of the most compelling arguments for belief in a Creator has been the observation that our universe is structured in such a way that life was able to emerge at all. If the universe's rate of expansion or the values of the gravitational, electromagnetic, or nuclear forces exceeded specific parameters, we would not be here to ask such thoughtful questions as the one posed here. The conditions necessary for life to develop appear to be more precise, and extraordinary, than previously believed.

Presently, inflationary theory has reduced the need to impose such finely calibrated conditions prior to the Big Bang. We are therefore less compelled to invoke the anthropic principle, suggesting that this magnificent universe was specifically designed for us or that it exists as it does because we are here to observe it. This could simply be viewed as another attempt to reinstate our special position in the cosmos.

So how can we as intelligent and informed individuals continue to believe in God? By abandoning some of the narrow doctrines we have embraced throughout history. It is now very difficult to maintain an anthropomorphic notion of God as a being in heaven, creator and ruler of the universe. But knowledge of modern physics does not preclude the belief in God as spirit. Intellectual achievement has not eradicated the need for spiritual fulfillment.

The roots of spirituality are to be found in our consciousness. Once certain portions of the universe developed self-awareness, it irrevocably altered what we could consider "natural." A schism was created between subject and object, inner and outer. These opposing poles maintain an interdependent relationship. One directly affects the other. For instance, as our consciousness develops, so does our understanding of the cosmos. Changes in accepted beliefs about the universe directly impact how we view ourselves.

This, in turn, affects our interpretation of events around us and how we approach them. The cycle continues. In this sense, we impart as much meaning to the universe as we derive from it.

Our evolving consciousness has allowed us to direct our attention beyond that which we can actually observe. We look past mere appearances in search of a deeper meaning that may lie within (or behind) the thing itself. This is reflected in our belief in a transcendent God, one who exists beyond space and time. Although physical laws have predominantly replaced the supernatural as an explanatory principle, our tendency to transcend the observable remains as prevalent in theoretical physics as it does in theology. We create hypothetical constructs to explain events we cannot experience. These constructs are accepted as real as long as they comply with our theories.

Our ability to extend our range of understanding and influence has allowed us to accomplish very much. Unfortunately, it has also made us acutely aware of our separation from the world. Our mastery over nature has estranged us from it. We attempt to reestablish the sense of connection or grounding that has been lost. These efforts lead many people to believe in an immanent God. Rather than being infinitely removed and essentially unknowable, this God resides immediately in and around us. We can look to be inspired (i.e., filled with spirit, breath) in our daily lives.

Most cultures have developed elaborate rituals and established guides to assist people in their search for the spiritual. Through specific practices, some people are able to experience moments that profoundly affect them. These experiences have often been described as creating a sense of oneness with the universe. The distinction between inner and outer disappears. Time is altered. We feel a sense of awe and humility in the face of a power far greater than ourselves. Many of us have achieved the same effect by silently gazing at a starlit sky. Our current knowledge about the universe in no way diminishes this experience. If anything, it adds to our sense of wonder at the tremendous beauty and complexity that exists around us.

Thomas L. Diana lives in Houston, Minnesota.

Why should a city government help to fight light pollution?

by Nora Steiner Mealy

My seven-year-old is our family astronomer. He sports a T-shirt picturing the Milky Way, with an arrow labeled "you are here" pointing to a tiny dot on a spiral arm. And he is always calling the rest of us to come outside, to see the phases of the moon, to point out the Big Dipper, the North Star, Orion, and whatever the current comet is at the moment. (He's seen so many in his short life, he regards them as almost commonplace.)

It's no miracle that he recognizes these landmarks, or rather, skymarks. Except for a smattering of a few other bright stars and planets, they are about the only things visible in our sky. The patterns of the few constellations he can distinguish stand out clearly behind the muddy, pinkish glow. There's not much else up there to distract him.

I can remember two times when my son could not be dragged outside at night. On a camping trip along the Columbia River gorge a few years ago, he took one glance at the sky, then fled inside our tent in terror. On another vacation in Hawaii, he could not be prodded to walk even three steps outside of our hotel room at night.

On those two really dark nights, when his shirt finally made some sense, the sky didn't. A good view of the sky looked positively freakish to him. His beloved skymarks were lost among the millions of stars that seemed to be pouring from the Milky Way. What he saw overhead was totally beyond his realm of experience.

The International Dark-Sky Association (IDA) can give you dozens of great reasons to convince your city council to work toward a more astronomy-friendly night sky. Lighting typically used in American cities wastefully throws light all around, instead of directing it downward where we need it. Light that scatters upward is bad for astronomers. And light that falls sideways, toward our eyes, only blinds everyone rather than illuminates. It actually makes it harder to spot a prowler in the shadows or a crack in the sidewalk. Think about someone shining a flashlight in your eyes, and you know that your pupils constrict when struck by light, reducing vision.

The IDA claims that with reasonable measures, we could not only darken sky glow, but also save perhaps 30 percent of our cities' annual operating costs of public lighting in the process. They estimate an annual savings of $200,000 a year in a city of 600,000. Hey, the city could purchase a decent little telescope for public viewing for that price.

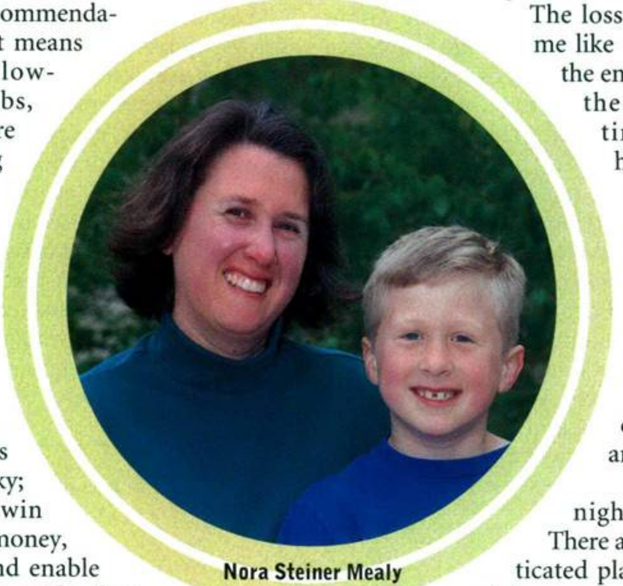
Cassiopeia
AMERI
VIRGO
Centaurus

Coma Berenices
Nova Hollandia
Corvus
Centaurus

By the way, our hotel room under that dark Hawaiian sky was not in an isolated tropical valley, but in the small city of Waimea, nestled below peaks holding some of the most powerful ground-based telescopes in the world. I'll bet my morning mango that this town, under the watchful dilated pupils of the research groups above, has adopted all the recommendations of the IDA. That means using low-wattage, low-pressure sodium bulbs, which direct light where it is needed, increasing visibility rather than glare and glow. When light is needed only occasionally, infrared sensor motion-detecting spotlights do the trick.

I wholeheartedly agree with the IDA's arguments for a dark sky; it sounds like a win-win situation. It will save money, conserve resources, and enable ground-based scopes to probe deep space — all without sacrificing public safety. But quite honestly, my gut-level reason for wanting a dark sky lies elsewhere. It has more to do with a book I read a few years ago — *The End of Nature* by Bill McKibben.

McKibben describes modern society, where people live under the delusion that they no longer need nature. After all, we can raise crops under artificial conditions, without much regard to seasons. We exercise indoors in gyms and malls. We entertain ourselves primarily in amusement parks or at home, in front of a screen. The Japanese have actually managed to bring the great outdoors safely inside: There, in shopping malls, people can swim in a totally man-made sea, complete with tides, or ski on artificial snow — indoors. And you don't have to go to Japan to appreciate "the wild." I hear that many trendy U.S. restaurants feature dining in indoor tropical rain forests.


Nora Steiner Mealy

The loss of dark skies feels to me like one more step toward the end of nature. For all but the current blip on the timeline of mankind, humans have sat outside and gazed at the beauty of a dark sky, brightly lit with stars. I don't doubt for a moment that this sight was nightly observed with awe and wonder by children and adults around the world.

Perhaps the loss of the night sky doesn't matter. There are some awfully sophisticated planetariums to show us what we are missing. And even with a dark sky out, most people would still spend their evenings indoors watching TV.

But I know it matters to many of us. A picnic at the beach inside a shopping mall is not the same as on the coast, and watching life on TV is not the same as living it. And much as I love visiting planetariums, it cannot compare to sitting outside with my kids, bundled in jackets, and experiencing the real, twinkling thing.

Nora Steiner Mealy lives in Davis, California.

What is the consequence of leaving our spacecraft debris in space?

by Tom Glennon

When we were children, our parents always tried to stress to us the importance of picking up after ourselves, whether it was our bedroom, or the basement, at the park, or the beach, they've always tried to instill in us a sense of responsibility and obligation to put things in their place.

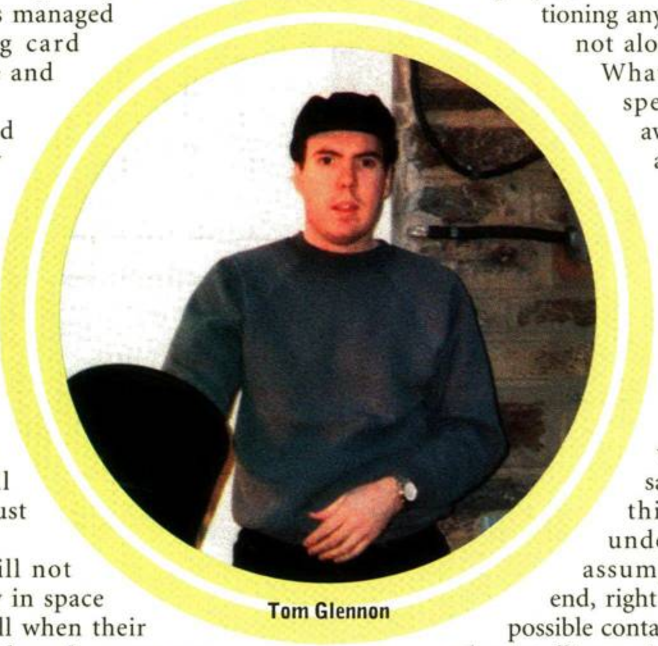
Of course, at first, we didn't really see any need to be so orderly, until one day when dad accidentally stepped on one of our favorite toys and broke it, or when our baby brother or sister almost swallowed that innocent looking piece of plastic or rubber that looked so appetizing.

So we learned the hard way, through experience, and we eventually came to respect things that were in order, because we became aware of the consequences if they weren't. Then we grew up, or at least we thought we did, and we seemed to forget about the importance of things being in their proper place and of the problems that soon followed if they weren't.

First it was the air. Since the dawn of the industrial age, we've poured countless billions and billions of tons of carbon dioxide into Earth's atmosphere without so much as a second thought, creating a greenhouse effect.

Then it was the oceans. Aside from the fact that we hunted and killed so many species of whales and other mammals almost to the point of extinction and that most of the ocean's coastal waters have been the victim of depletion, we have polluted our oceans with large amounts of medical and chemical toxic wastes to the point where most of the marine ecosystem has been affected.

Now it's space, "the final frontier." Since the dawn of the space age 40 years ago, humankind has managed to leave its calling card even in this remote and desolate place.


Tom Glennon

We have managed to put approximately 8,000 separate and distinct objects in permanent orbit around our planet. These consist of spent booster rockets, shrouds, other miscellaneous debris, and, of course, the payloads themselves. It is all space junk, which just doesn't belong there.

These objects will not remain permanently in space because they will fall when their orbits decay. And though many are relatively small, we must consider that they are traveling roughly 18,000 miles per hour, circling Earth every 90 minutes.

We are all too familiar with the effects that a small piece of lead the size of a fingernail has on an object when it strikes it at nearly 2,000 miles per hour. Now, try to imagine what would happen if an object the size of your fist traveling 10 times the speed of a bullet had actually hit something.

I am fully aware that the North American Air Defense Command keeps track of all of these satellites, but what if something happened to their computers that made their tracking devices inoperable, say, even for a short time. Most of the 8,000 artificial satellites are so small that only sophisticated radar devices like NORAD's can detect them. The space shuttle itself must occasionally dodge a piece of this debris in order to prevent damage to its protective heat-shield tiles.

Starting this summer, NASA will begin construction on the international space station, and it will be built entirely in space, requiring frequent long and dangerous space walks, with astronauts becoming human satellites.

And then there are the future civilian space flights. In just a few years, NASA will have the capability to fly civilians into orbit on a space plane. Last but not least, there is the Hubble Space Telescope, an invaluable tool for exploration.

Can you imagine the potential damage to any one of these projects if they come in contact with just one of these artificial satellites? Can you imagine the possible lawsuits against NASA if they allowed a catastrophe like that to happen to a civilian space flight. That alone could jeopardize the space program's future.

And finally, I'm going to suggest a scenario that may seem a bit too far-fetched for most people, but I feel it is worth mentioning anyway. What if we are not alone in the universe? What if there are alien species "out there," aware of our existence and very willing to openly meet and communicate with us? Suppose they sent a scout party ahead to make a close encounter with us, like in the movies, and they came in contact with an artificial satellite? Would they think that they were under attack, a logical assumption? That could end, right then and there, any possible contact we may have with other intelligence in the cosmos, or, at the very worst, touch off an interstellar war.

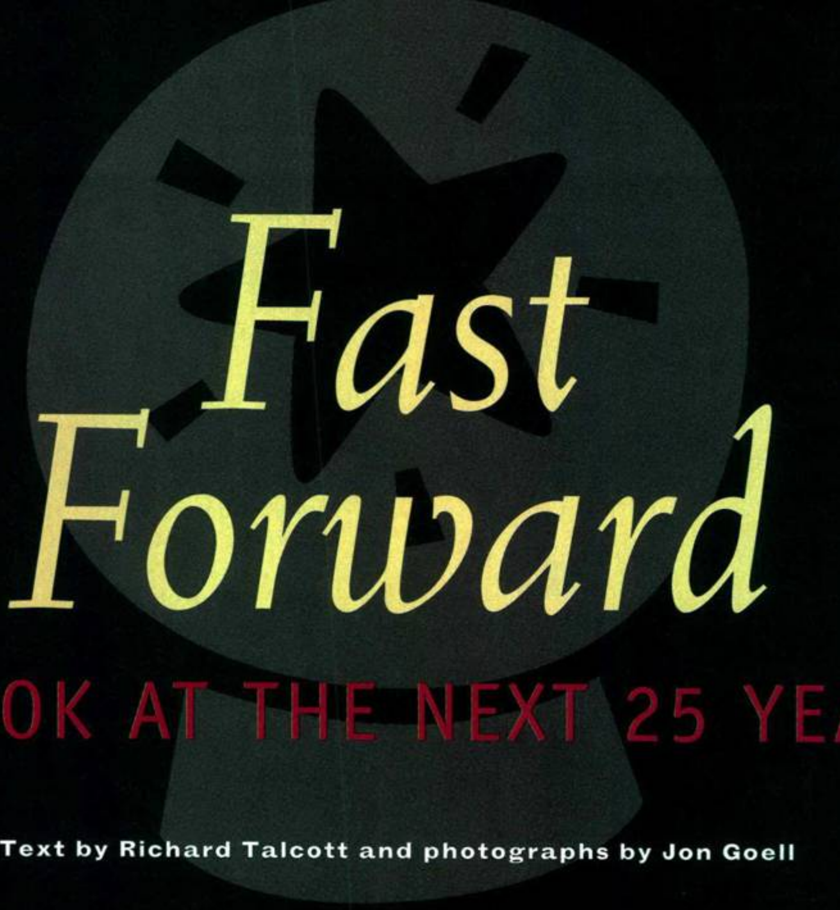
Are we willing to let such potential catastrophes, as remotely improbable as they may seem, linger over our heads? More importantly, are we prepared to deal with the consequences if such events as these became a reality?

After all the damage we've done to this planet, isn't it about time we started being responsible by picking up after ourselves and "putting litter in its place" before it gets out of hand? Haven't we learned the hard way, through our mistakes on Earth, that an ounce of prevention is indeed worth a pound of cure. Isn't it bad enough that we polluted our own planet? Do we really have to spread it out to space as well?

Philosopher and poet George Santayana once said, "Those who forget the past are condemned to repeat it." Are we still so arrogant that we feel that all the universe is ours for the taking, as well as ours for the dumping? If we're going to explore the universe, shouldn't we at least leave our trash back home? ▣

Tom Glennon lives in Philadelphia, Pennsylvania.

Calsiopeia
VIRGO
Corvus
Centaurus



Fast Forward

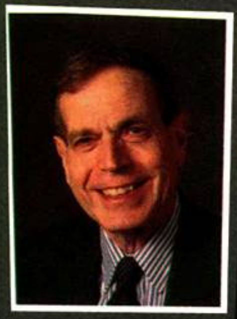
A LOOK AT THE NEXT 25 YEARS

Text by Richard Talcott and photographs by Jon Goell

To help us celebrate the 25th anniversary of *Astronomy,* the magazine's editors invited these nine sagacious astronomers to meet for lunch in Washington, D. C., in January to predict what the next 25 years hold for astronomy: **Alan Boss** of the Carnegie Institution of Washington, **Martin Harwit,** former Director of the National Air and Space Museum, **Anne Kinney** of the Space Telescope Science Institute and an *Astronomy* advisory board member, **John Mather** of NASA's Goddard Space Flight Center, **Bohdan Paczynski** of Princeton University, **Vera Rubin** of the Carnegie Institution of Washington, **Michael Shao** of the Jet Propulsion Laboratory, **Alex Szalay** of Johns Hopkins University, and **James Trefil** of George Mason University and an *Astronomy* advisory board member.

What does the future hold? Who among us hasn't peered into the mysterious mist that stretches before us and wondered? It is a question that scientists don't always like to answer, particularly when their musings can be compared with the actual discoveries of the next millennium. Any scientist might feel silly having predicted that the universe is 10 billion years old, when later it is proved to be much older. But *Astronomy* found these nine astronomers fearless enough to make general and specific predictions. These are excerpts of their comments at a luncheon held during the 1998 annual meeting of the American Astronomical Society:

Alan Boss



Martin Harwit

Anne Kinney

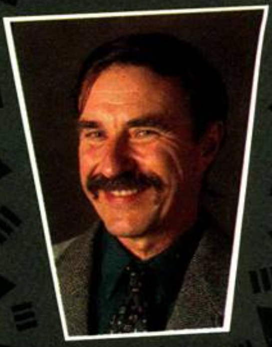
John Mather

Bohdan Paczynski

Vera Rubin

Michael Shao

Alex Szalay



James Trefil

DISCOVERY SPACE

Astronomy: What do you think about the possibility of discovering new and surprising phenomena in the universe in the next 25 years?

Paczynski: That raises the question of which discoveries over the last 25 years were really surprising. About 25 to 30 years ago, there were, to my mind, a few major, surprising discoveries — the microwave background, quasars, and pulsars. I well remember that prior to the discovery of pulsars, most astronomers had no doubt that neutron stars could not exist. And then they were discovered. I think the most surprising discovery I can recall in the past 25 years was that of planets around pulsars. Because again, ahead of time, if you asked any theorist, he could prove to you that such things could not exist.

EXTRATERRESTRIAL WORLDS

Astronomy: Speaking of exciting discoveries, how common do you think planets, and in particular Earth-like planets, are in our Milky Way Galaxy?

Boss: I think it's pretty safe to predict that within the next 25 years we will have a pretty complete census of at least the more massive planets around most nearby stars. And NASA is talking about launching the Planet Finder as part of its Origins program in the year 2010 or so. That would be a potent instrument not only for detecting and imaging Earth-like planets but also for studying their atmospheres to see if they are habitable. I think if we have the national will to build that instrument and fly it, we can safely predict that we will know the answer to that question within 25 years.

Boss: To pick up on the point that Bohdan made, I agree totally that the discovery of the pulsar planets is one of the most surprising things in the last 25 years. On the other hand, I think the discovery of the first extrasolar planet around a solar-type star was one of the more satisfying discoveries because it had been anticipated for hundreds of years. I hope 25 years from now we will have a large enough number of them where you can do statistics and really begin to address the issue of life elsewhere around nearby stars.

Kinney: My guess is you'll find that planets are ubiquitous, but planets like ours will be very rare. Never mind finding life or intelligent life, I mean just liquid water.

Szalay: My feeling is that if there is a planet about the size of Earth and in a similar orbit, the probability is fairly high, tens of percent, that there will be liquid water on it.

Paczynski: There's more than one in our solar system. Europa (one of Jupiter's moons) supposedly has liquid water.

Boss: I think NASA will do a serious search for life on Europa before 25 years have elapsed. And without a doubt we'll know more by then about life on Mars.

ORIGINS OF LIFE

Mather: We still think life is pretty near everywhere that there is water. My feeling is we're not going to find very many places where we can check this out. But every place there is water and chemical energy of some sort, there will be . . . something. We just aren't going to be able to find out for a heck of a long time. Mars is now pretty inhospitable and if there's any life I would guess it's probably pretty hard to find. And if there's any on Europa, it's under miles of ice and that's a pretty hard problem too even if you are NASA.

Harwit: You don't seem to have to have liquid water. You have bacteria that have a metabolism based on sulfur, others that are dependent on iron, and they exist deep down in the Earth's mantle where water is very scarce.

Trefil: But did they start there or were they transported there?

Harwit: Well, that we don't know. But the chances are that they started there because if you trace back the genetic tree to its root, all of the currently identified organisms on that root are thermophilic. This suggests that the beginnings of life were in the hot springs or very deep down where it's hot.

Mather: I think biologists will tell us a lot about this part of astronomy. These findings have been really surprising to me lately because I didn't anticipate all this thermophilic stuff being so different or so prevalent. People now claim that most of the biomass on Earth is underground.

Rubin: I think that's one of the real surprises of the last several years. The fact that you can discover something so fundamental, and that it has been unknown until now, is remarkable.

Martin Harwit, right, makes a point as associate editor Richard Talcott, middle, and Alex Szalay listen.

GALAXY FORMATION AND EVOLUTION

Astronomy: What do you think astronomers will discover, in 25 years, about how and when galaxies form and evolve?

Paczynski: It will be seen directly, with the NGST (Next Generation Space Telescope).

Kinney: And probably in less time than 25 years. I imagine that within 10 years we're going to have a much clearer picture.

Mather: I'm astounded at the rate of progress that's being made. It's very hard to predict how far we're going to get. But in some sense, the questions we are now thinking about for NGST are going to be old by the time we get to them, and we're going to have a whole new batch by then.

Paczynski: I can give you an analogy that is probably reasonably accurate. Over the next 25 years, we shall learn observationally about galaxy evolution and formation just as we learned about stellar evolution during the previous 25 years. The theory of stellar evolution is in very good shape because it is well guided by observations.

Astronomy: What will astronomers learn in five or 10 years about the formation, distribution, and long-term evolution of galaxies that we don't already know?

Rubin: We'll know in what era the galaxies formed and how important mergers are.

CORES OF GALAXIES

Kinney: I think we'll also learn the connection between active galaxies and normal galaxies and whether activity is a normal phase in every galaxy's lifespan or just a phase in the lifespan of a subset of the galaxies. For example, we're learning whether every galaxy has a black hole in the center of it. That's what Hubble (the Hubble Space Telescope) is doing.

Paczynski: And I hope that 25 years from now we shall know what came first — galaxies or supermassive black holes.

Anne Kinney predicts large galaxies will have black holes. James Trefil wonders what value society places on science.

Astronomy: Do all galaxies have quasars in their nuclei; that is central black holes ingesting matter within their gravitational reach and emitting intense radiation in the process?

Kinney: I would say most people would probably guess that every moderate to large galaxy has a black hole in it. And then perhaps it's just a question as to whether the black hole is actively being fueled (swallowing nearby objects) at the moment, which makes it active. And if it's not being fueled, then it looks like a normal galaxy.

Astronomy: So would you agree that the consensus among most astronomers is pro black hole?

Rubin: Yes. Some people were even saying that 25 years ago.

TELESCOPES OF THE FUTURE

Astronomy: How do you see the future of ground-based versus space-based astronomy?

Mather: Obviously, wherever Earth's atmosphere is opaque, you really have to be in space. There are many wavelengths where the atmosphere is too warm or a telescope on the ground is too warm. At short, visible-band wavelengths you can't see out clearly because the atmosphere is turbulent. There's a lot you can do to overcome it with adaptive optics, but it's only moderately successful at the short wavelengths. So there's another place where you need to go into space. Remember Hubble has been able to do things that are pretty tough from the ground even though it's only a quarter as big as Keck (the twin 10-meter telescopes in Hawaii). But in terms of developing new instrumentation and new techniques, anything you can do on the ground is always so much cheaper that we'll do that first, if possible. Cost has been a tremendous impediment to going into space in the past. I think we are gradually learning how to do things cheaper as well as better, the challenge that (NASA Administrator) Dan Goldin has set for all of NASA.

Astronomy: Yes, but won't NGST be less than half the cost of the Hubble, but have a larger mirror than the Hubble?

Mather: It's supposed to be. Well, it is, because we won't get to do it if we can't figure out how.

FUTURE OBSERVING MAY BE . . .

Shao: But I think there's another question: Will at some point ground-based astronomy simply cease to exist because everything will be done in space? My feeling is that within the next 25 years, that probably won't be the case: There will be a lot to be done on the ground.

Szalay: There's an interesting comparison you can make with particle physics. It went through the cyclotrons, the accelerators, and then the big national labs. And now there are only a few international facilities like CERN and Fermilab. I think astronomy is tracking a similar trajectory, except with a 25-year delay. So the 4-meter telescopes were a little like the cyclotrons and now Keck (with twin 10-meter mirrors) is like the Fermilabs and CERNs of astronomy. How far can it go? The next generation may be so expensive that probably no single university or even nation can afford it.

Trefil: There's been sort of a rule of thumb that the most expensive telescope costs as much as the most expensive highway interchange. Is that rule going to be violated soon?

Shao: I don't think so.

Harwit: There is an important social question: What is science's worth to society? Currently the billion-dollar level, maybe stretching to $10 billion in some cases, is the major science shutoff. You can't go beyond that. It's not worth it to people.

. . . CHEAPER,

Boss: Let me just make another comment that follows up on that, which is that there are some things, blessedly, that are becoming cheaper and useful for theorists as well as those who manipulate data, and those are personal computers. They're tremendously less expensive than what they were even 10 years ago. I recently got a PC that runs 600 times faster than the VAX I used about 14 years ago and the PC costs 20 times less. That's a factor of 10,000 more speed per dollar. If we maintain that pace, then 25 years from now we'll have enough computational power to solve a huge number of problems in astronomy.

. . . FASTER,

Szalay: Computers and the new large observational databases are going to cause a dramatic shift in the way we do science. For a lot of smaller projects, rather than trying to get telescope time, waiting for a year, and then getting two nights on a one-meter telescope, one can actually just dial up the sky in 10 minutes and get data on the same object not only in optical but in ultraviolet, infrared, and x rays as well. It is so easy with computers to gather data at enormous rates, but to make sense of them is going to be much harder.

. . . AND MORE LIBERATING

Trefil: I remember having a conversation with Allan Sandage where he was sort of lamenting the fact that in the good old days the best discoveries went to the guy with the best pair of kidneys because he could stay in the observation dome for a long time. What's this going to mean to you as astronomers?

Paczynski: Only a quarter century ago, most observing on big telescopes was done in environments like the one in this room: air conditioned, music playing — no kidney problems.

Rubin: About a quarter century ago, women were not allowed in many observatories. The whole sociology of the time was different. The makeup of this very elite group has changed so that astronomy has become accessible to many more people.

Michael Shao, left, associate editor Robert Naeye, and John Mather enjoy the panel's lively discussion.

FATE OF THE UNIVERSE

Astronomy: Astronomers seem to be closing in on some of the key cosmological parameters, such as the density of the universe, also known as omega, and the Hubble constant, which defines how fast the universe is expanding. We'd like to get your thoughts on what we'll know in 25 years about the age and ultimate fate of the universe.

Rubin: I think 25 years from now you'll be making these same statements. I think we're just about closing in on omega and the Hubble constant; but I also think that the universe is enormously complicated and that there are very many things we don't yet know. By the way, neither the Hubble constant nor omega will give you the answers that you want about the universe. I hope someone will disagree.

Paczynski: I'm modestly confident that omega and the Hubble constant will be known to within a few percent accuracy. I agree in the sense that there will be surprises. But I think they'll be of the type you cannot really envision right now. One I hope for is that the next generation of microwave background experiments will make it possible to establish the topology of the universe. You might, for example, see the same object in the universe in different directions. This would be a spectacular thing and would change our views fundamentally.

Trefil: There's a joker in the pack here, which is the cosmological constant (a hypothetical repulsive force that could play a major role in the universe's expansion). Are we going to get rid of that in 25 years?

Paczynski: No, I think we will measure it.

Mather: We'll know what it was at the time the microwave background formed. At least that's the plan.

Rubin: But we're still only discussing the questions we know enough to ask.

Paczynski: Sure. This is the predictable future. But there will be the unpredictable as well, I hope.

Harwit: This assumes that general relativity holds on a scale that we haven't yet ascertained that it will. If general relativity doesn't hold, then constants like omega are not defined entities and the cosmological constant doesn't make any sense. If we find an answer, then we'll also know that general relativity gives a good description of space and that will give us a lot more confidence in what we are actually doing.

Mather: I think there are many questions that are so hard that they'll still be here for a long time. After all, the 200-inch telescope at Palomar was built to tell us how fast the universe is decelerating (an idea now questioned by some), among other things, and we still don't know. And that was 50 years ago.

Editor Bonnie Gordon, listens with the panel as Vera Rubin, center, says, "There are very many things we don't yet know."

Harwit: So if general relativity holds, it looks fairly optimistic that some of these elementary constants are going to be known in 25 years to within maybe 50 percent or 10 percent or something like that. But that doesn't really mean we know a huge amount. It's like finding an object and saying, "Well it's round." It doesn't tell you the chemistry, it doesn't tell you the color. There's a lot to be done still.

The (three-dimensional deep-sky) surveys, like the ones you're doing Alex, are likely to give us glimpses long before we actually have instrumentation to do these things globally. And I think astronomy has always gone ahead on that basis — of glimpses that tell us what projects might be worth building instruments for. And these huge surveys where you have hundreds of millions of objects are going to turn up all kinds of things.

Szalay: Even if you measure omega, it's still an open question as to what constitutes the dark matter and how we go about finding out what it is.

DARK MATTER

Trefil: What about the searches that are going on now looking for Weakly Interacting Massive Particles (WIMPS, a type of exotic dark matter that may have formed after the Big Bang).

Paczynski: They may find something, but there's no guarantee. And Massive Compact Halo Objects may be found. (MACHOs are objects like brown dwarfs or planets whose signature is the occasional amplification of the light from extragalactic stars by the gravitational lens effect.) Microlensing has been found, but it's not clear whether it has anything to do with dark matter or not. We just don't know. That particular issue will be settled when the Space Interferometry Mission (SIM) goes up — which will be able to measure the mass and distance of any lens just looking at its position. Then, with some luck, it may turn out to be some dark objects. If we are not lucky, it may turn out to be just brown dwarfs or something like that.

Mather: One thing we claim that we will know about dark matter will be based on the microwave background fluctuations, which will tell us how much dark matter there is and how much of it is hot and how much is cold. I think it's a startling change in perspective that's happened since the background fluctuations were found, that there's much more that you can learn from them than we ever dreamed in the beginning.

Paczynski: I remember when inflation was first proposed and it was claimed that it predicts a universe with a critical density (the density at which the universe is "flat" and its expansion slows to zero at infinite time), but now I hear that a density 30 percent of that is quite natural for inflation (a density at which the universe is "open" and expands forever). I think inflation is a great concept, though I'm not sure it's a scientific theory.

Trefil: Why do you say it's not a theory?

Paczynski: At this point, there is enough freedom in the concept. It's flexible enough that you cannot disprove it. No matter what comes from observation, you can say, "It is consistent with the theory."

Trefil: Do you reach a point where you just can't adjust it any more?

Chorus: No!

Mather: I think this one will be pretty well known in about five years with the Microwave Anisotropy Project (MAP). That should be launched in 2000, and we should start to get analysis a few years after that.

Astronomy *associate editor Richard Talcott believes that 25 years from now, astronomers will recognize how much more there is to learn.*

25 New Citizen

s of the Cosmos

Joe Tucciarone

by Rex Graham

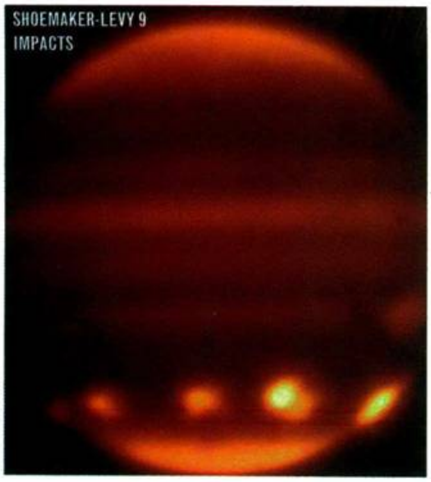
George Smoot made one of the most important astronomical discoveries of the past 25 years — detecting the first tiny temperature variations after the Big Bang — and then refused to believe it for months. "We deliberately focused on worrying about the potential problems before we started taking the results seriously," says Smoot, an astrophysicist at the University of California at Berkeley and the Lawrence Berkeley National Laboratory. "You can't let your desire or excitement about your result sweep you away."

Often science is settled with the passage of time. The years have given proportion to many of the discoveries made since *Astronomy* was founded in 1973. During that time, astronomical knowledge has exploded — we could have made a list of 25,000 "new citizens of the universe." Here's our take on 25 of the most noteworthy new citizens to appear in the past 25 years.

Asteroid Hazard

We left the one-mile-wide asteroid called 1997 XF_{11} off the list. Like many tantalizing findings of the past 25 years, the asteroid riveted the world's attention, but only briefly. Within days of its announced discovery, pictures taken years earlier helped pinpoint XF_{11}'s path and showed that the asteroid will not come within 30,000 miles of Earth in 2028, as first feared, but will sail 600,000 miles wide of us.

The public may have felt a little whipsawed by the headlines, but there was nothing unscientific about the flip-flop. It is all part of the way science



SHOEMAKER-LEVY 9 IMPACTS

Univ. of Hawaii

sometimes works and gets reported. We salute astronomer Jim Scotti for discovering XF_{11} and astronomers Eleanor Helin, Kenneth Lawrence, and others for helping to determine its less scary path. In all, roughly 120,000 asteroids have been discovered by dozens of professional and amateur astronomers, most of them in the past 25 years and some of them with orbits that intersect Earth's. "In the past 20 years, what we had was the discovery of the impact hazard itself. That," says asteroid expert Tom Gehrels, "is the major discovery."

No-Name Killer

A now famous extraterrestrial citizen of the universe that actually did strike Earth has no name. Scientists don't know for sure whether it was an asteroid or a comet, but it hit the Yucatán of eastern Mexico. A Nobel laureate, physicist Luis Alvarez, and his geologist son Walter announced in 1979 that they had found abnormally high levels of the element iridium, which is a thousand times more abundant in primitive meteorites than in Earth's crust, in a highly unexpected place — a narrow band of sedimentary rock. The layer is known as the K-T boundary and is the chronological boundary between the Cretaceous and Tertiary eras about 65 million years ago, the time of the abrupt disappearance of the dinosaurs and many other species of life.

Comet Shoemaker-Levy 9

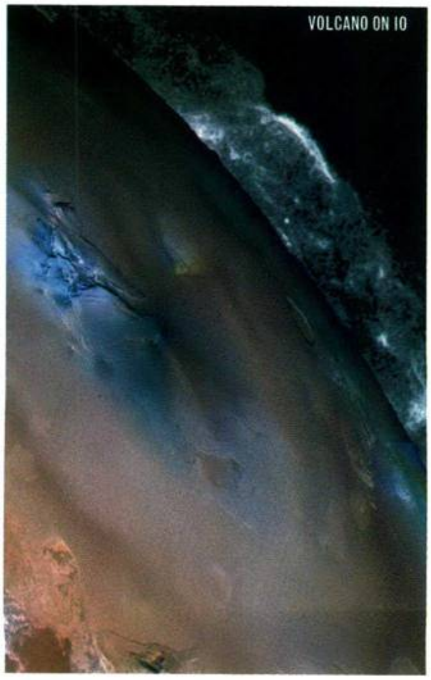
The collision of the more than 20 fragments of Comet Shoemaker-Levy 9 with Jupiter continued for seven days in July 1994. The comet, discovered by astronomers Carolyn Shoemaker, her husband Eugene Shoemaker, and David Levy, had fragmented into a "string of pearls" during an earlier pass around Jupiter. The unexpectedly large effect of the impacts — plumes seen rising above Jupiter's limb and dark splotches that lasted for months — helped drive home the danger of such impacts throughout the solar system.

Io the Dynamo

The first volcanoes seen erupting beyond Earth turned up on Io, a moon of Jupiter that is stretched and heated by a gravitational tug-of-war between Jupiter and that planet's other large moons. The two Voyager spacecraft in 1979 and the Galileo spacecraft in the past three years photographed Io's volcanic plumes in detail and, along with ground-based infrared telescopes, monitored intense hotspots on the satellite's surface. The discoveries are important, in part, because life may have arisen on Earth near volcanically active rifts on ocean floors.

Kuiper Belt

Gerard Kuiper died 25 years ago, before the discovery of his postulated belt of icy rocks beyond Pluto that might extend out to 35 to 50 astronomical units (an AU is the average distance between the sun and Earth, 93 million miles [150 million km] or 8.3 light-minutes). Astronomers David Jewitt and Jane Luu discovered the first Kuiper belt object in 1992, a 125-mile-wide (200 km) object called $1992QB_1$. Many others have since been discovered. "The first one was big news because it was first, but it in itself was nothing special," says Luu. "It confirmed that the solar system did not stop at Neptune or Pluto."



VOLCANO ON IO

USGS

PRIME INGREDIENT

Phil Lauro

Chiron

The picture of the solar system changed further in 1977 with the discovery of the asteroid-turned-comet Chiron. Chiron is the first discovered and largest member of a group called Centaur objects, asteroid-sized bodies that orbit the sun in the realm of the giant planets.

Proto-Planetary Disks

In 1994 astronomer Robert O'Dell discovered swirling disks of dust and gas around 56 of 110 stars about 1,500 light-years from Earth in Orion. It is from these disks that planets are believed to form. Other such disks had been reported, but not nearly as many in one place.

Beta Pictoris

Remember the name Beta Pictoris. Observations since the early 1980s of this star about 60 light-years from Earth hint at a "clear" inner zone about the size of our solar system and an outer zone, or disk, of material, possibly made up of comet-like bodies. Recent observations of a handful of other stars clearly show similar clear zones inside dusty disks. Although any planets around Beta Pic would be too faint to spot with existing telescopes, the disk is warped in a way that indirectly suggests they are there.

Extrasolar Planets

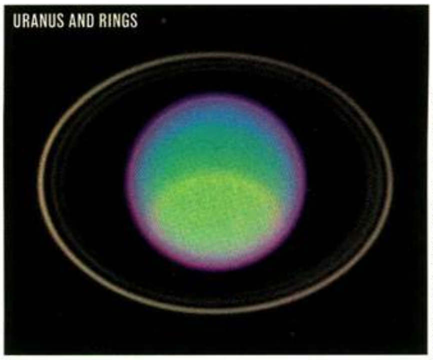
Astronomer Alexander Wolszczan reported in 1992 that he found clear evidence of two objects orbiting a pulsar, the rapidly spinning, collapsed remnant of an exploded star. His startling finding was later confirmed. It amounted to the first definitive evidence that planets exist outside our solar system, even if they were in a most unlikely location.

51 Pegasi

Astronomers Michel Mayor and Didier Queloz went Wolszczan one better in 1995 when they announced that a *sunlike* star lying 50 light-years from Earth, 51 Pegasi, has a planet orbiting it. They had detected a slight wobble in the motion of 51 Peg caused by the gravitational pull of the planet. Astronomers Geoff Marcy and Paul Butler confirmed the Mayor and Queloz discovery, suggesting that an unseen companion about half the mass of Jupiter orbits the star at an intimate distance of 0.05 AU.

Prime Primordial Ingredient

If life exists beyond Earth water must be involved. Astronomers have found evidence for water or its cousin, ice, on the moon, Mercury, Jupiter's moon Europa, and in the Orion Nebula. Water was even detected in clouds spinning at high speed around a suspected black hole at the center of the galaxy known as Markarian 1. It is about 200 million light-years from Earth in — no, not Aquarius the Water Carrier — Pisces the Fish.



URANUS AND RINGS

E. Karkoschka (Univ. of Arizona) and NASA

Rings Revealed

Rings around Uranus were discovered accidentally in 1977 by astronomer James Elliot and his colleagues. They were viewing a faint star as Uranus approached it when the star suddenly disappeared from their view — a phenomenon called an occultation. Astronomers subsequently learned that Uranus has 11 rings. Rings have since been discovered around Jupiter and Neptune.

The Eagle Nebula

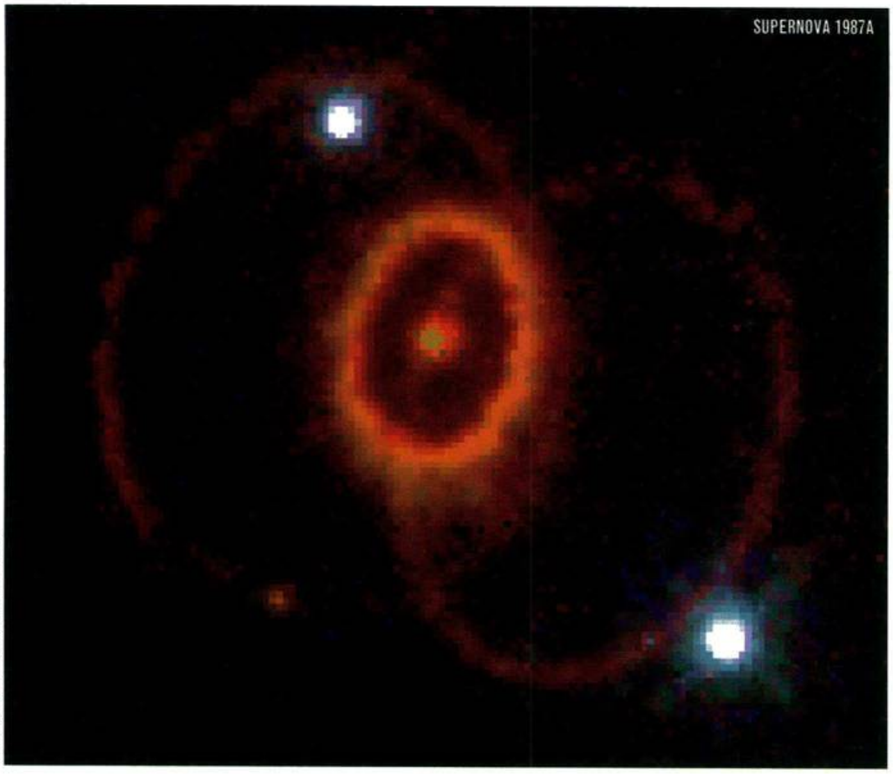
Of the more than 100,000 images taken by the Hubble Space Telescope, few are as inspiring as the one taken in 1995 of the newborn stars twinkling to life at the ends of vast pillars of dust and hydrogen gas in the Eagle Nebula.

Top Quark

How many physicists did it take to find the top quark? It took 440 talented ones to find evidence that "points strongly" to the discovery of the weird

THE EAGLE NEBULA

J. Hester and P. Scowen (Arizona State Univ.) and NASA



SUPERNOVA 1987A

Christopher Burrows, ESA, and NASA

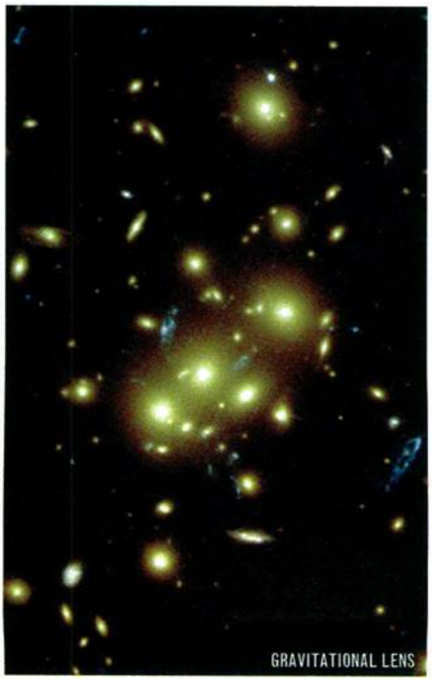
and elusive quark, one of the six types of quark — subatomic particles that appear to have no structure and are the building blocks of ordinary matter. The physicists discovered the top quark in 1994 by colliding protons and antiprotons. The top quarks generated have masses as heavy as an atom of gold, so big as to sound nearly impossible. "That's what's so interesting," says Fermilab physicist Rocky Kolb. "Eventually, it will unlock the secrets of mass in the universe."

Brown Dwarf GL 229B

An object orbiting the star Gliese 229, called GL 229B, is about the diameter of Jupiter and 20 to 50 times more massive, but too cold and with too little mass to be a star. It is the first definitive discovery of a brown dwarf. "There are important implications for this," said the discoverer, astronomer David Golimowski. "This could be considered a form of ordinary dark matter which would give our galaxy and presumably all galaxies a great deal more mass than the amount of light we see coming from them would otherwise imply."

Deuterium

Hydrogen, with one proton and one electron, is the simplest element. Just after the Big Bang, neutrons occasionally stuck to hydrogen nuclei to form a slightly heavier isotope of hydrogen called deuterium. Cosmologists realize that the amount of deuterium created in the Big Bang would indicate how much ordinary matter the universe contained. In 1997, astrophysicists Scott Burles and David Tytler measured the ratio of deuterium to hydrogen in the primordial universe: It suggested that most mass in the universe is not of the ordinary variety but is instead some mysterious kind of invisible, exotic dark matter.



GRAVITATIONAL LENS

W. Colley and E. Turner (Princeton), J. Tyson (Lucent Tech.), and NASA

Superluminous Stars

Eta Carinae is a superluminous eruptive star roughly one million times brighter than our sun. In the 1980s astronomers learned that it has lost one to two solar masses since it first erupted in the mid-1800s. Brighter than Eta Carinae is the Pistol Star. It throws off 10 million times more light and is 100 times more massive than our sun.

Supernova 1987A

A star died 160,000 years prior to February 23, 1987. That night was like most others for astronomer Ian Shelton until his photograph registered the sudden appearance of a very bright object in the Large Magellanic Cloud, a companion galaxy to our own Milky Way. The bright object hadn't been there before. The flash with the brilliance of nearly a billion suns was generated by the explosion of a massive star, a supernova 160,000 light-years from Earth.

Gamma-Ray Bursters

Two sudden, short-lived bursts of gamma rays even more violent than supernovae were spotted in 1997. Called GRB 970228 and GRB 970508, they were just two of the roughly 300 such bursts of intense high-energy radiation seen each year. Yet for the first time, optical counterparts of these bursts were located, which helped prove that they lie in the distant universe. What are GRB 970228, GRB 970508, and other such bursters? "That's the million-dollar question," said astronomer Kalish Sahu.

Great Attractor

This powerful gravitational force about 300 million light-years from Earth pulls the Milky Way and millions of other galaxies toward itself. Its discovery in 1986 confirmed that the largest structures in the universe are not mere clusters of galaxies, but "continents" of galaxies.

Black Holes

Black holes are hard to find because not even light can escape their intense gravity. But the discovery of rapidly rotating disks of gas spiraling toward the center of the elliptical galaxy M87 and the center of the spiral galaxy M106 — the first such observations — "shifted the debate from the existence of black holes to their demographics," said astronomer Holland Ford.

Gravitational Lenses

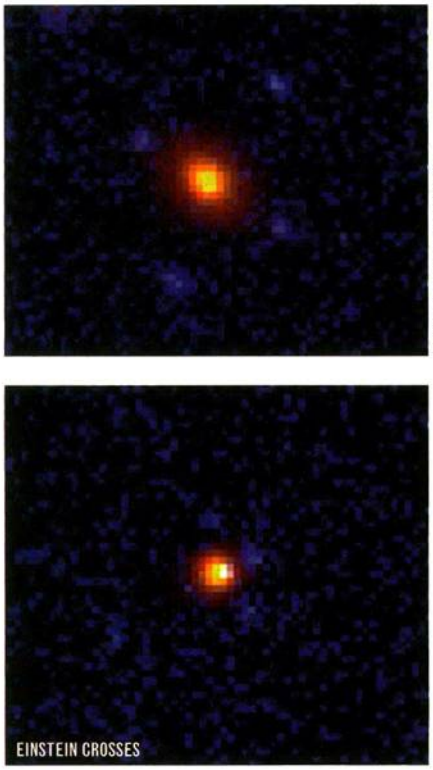
Hold a drinking glass up to a single light and you will see multiple lights through the glass. That is similar to the gravitational lensing effect that astronomers have seen in the past 25 years. In many of those cases the lights were quasars, bright centers of distant galaxies, and the drinking glasses actually were the mass of foreground galaxies whose gravity "bends" space-time, as predicted by Albert Einstein.

Most Distant Galaxy

The universe is like a loaf of raisin bread rising — the farther apart the raisins are from one another, the faster they travel away from each other. Galaxies behave like the raisins in raisin bread, and a galaxy discovered earlier this year is moving the fastest of any yet found. The light from this galaxy is displaced to longer, or redder, wavelengths. Its redshift was measured at 5.64, which means that the galaxy existed when the 10- to 15-billion-year-old universe was less than a billion years old.

Primitive Clouds

For the first stars to have formed in galaxies sometime within the first billion years following the Big Bang, there must have been something to give rise to those stars. Astronomers in the 1980s reported the detection of clouds of primordial hydrogen and helium, elements created in the Big Bang, which appeared uncontaminated by heavier elements cooked up later in the nuclear furnaces of stars.


EINSTEIN CROSSES

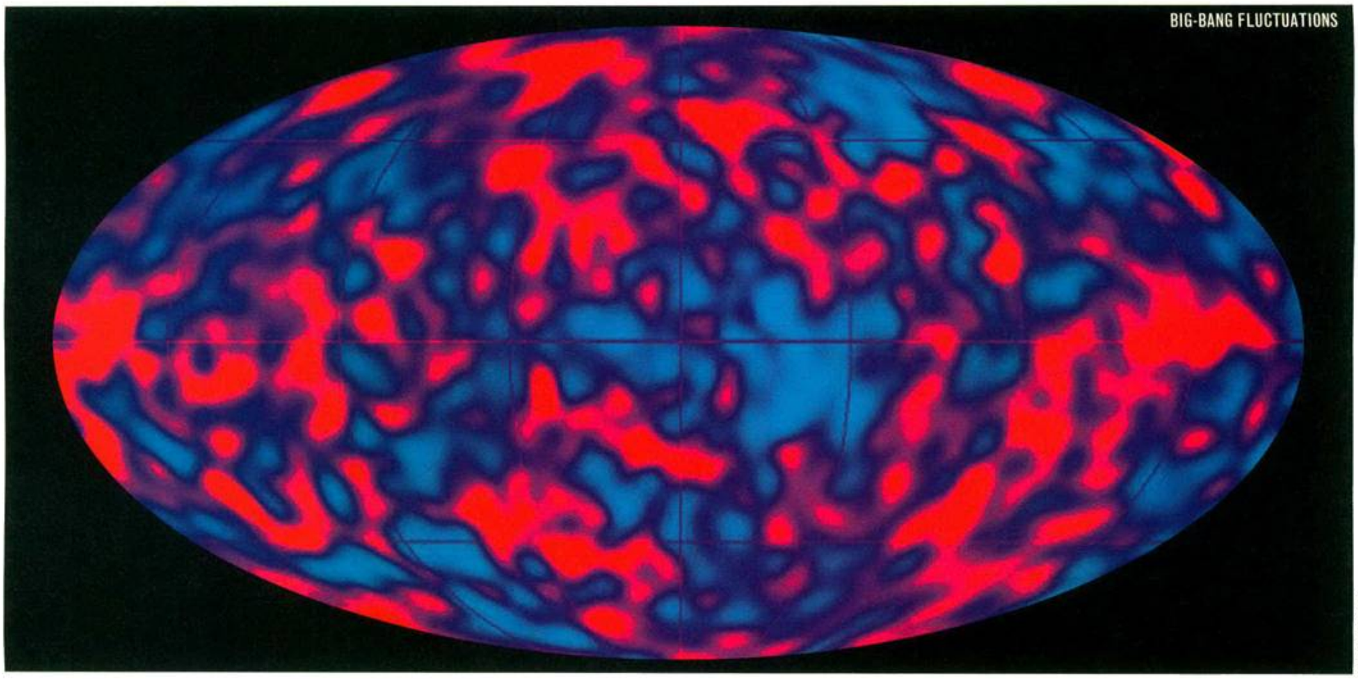
K. Ratnatunga (JHU) and NASA

First Primordial Flicker

The earliest observed feature in the universe was seen by radio astronomers Arno Penzias and Robert Wilson in the mid-1960s. Those and subsequent observations of this cosmic background radiation revealed that the early universe was incredibly hot, but incredibly uniform as well. During four years of observations with NASA's Cosmic Background Explorer, George Smoot's team also collected background microwave radiation equivalent to that needed to power a 100-watt light bulb for a scant 0.00000001 second. That isn't much, but it was enough to show that temperatures varied from place to place in the early universe by about 0.00003° C. Again, that may not sound like much, but any such variations, even tiny ones, could act like "seeds" to explain the coalescence of galaxies and clusters of galaxies.

"We spent about five months going through the data very carefully to make sure it wasn't something instrumental," says Smoot. After he repeatedly analyzed his technique and his data he sifted it through a fine mathematical screen to see if the amplitudes of power were the same at all angular scales. His results indicated real temperature variations, but Smoot asked his graduate student, Charley Lineweaver, to independently duplicate his work. The next morning Smoot opened his office door and looked down at Lineweaver's computer results. Lineweaver had slid the results under Smoot's door and placed a one-word note on top. The message reflected the terror of reporting an important discovery to the world: "Eureka?"

Smoot announced his discovery April 23, 1992. "This tells you how things started," Smoot says. "These fluctuations are the oldest and the largest things in the universe."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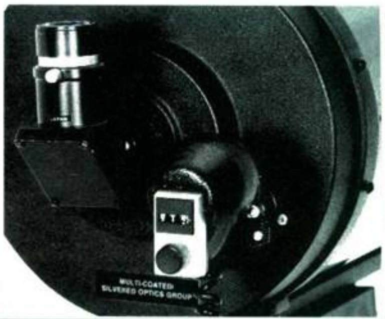

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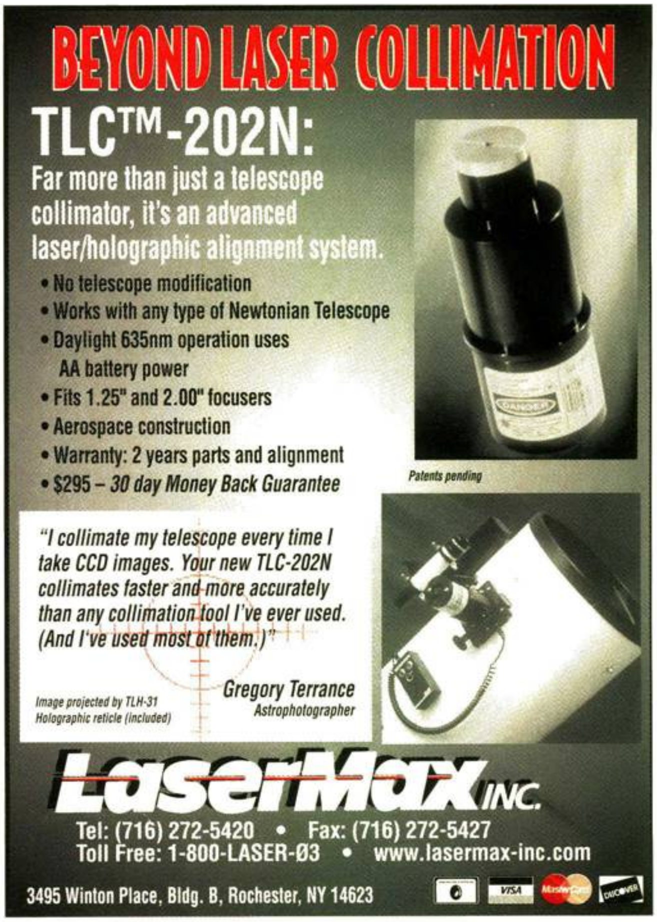

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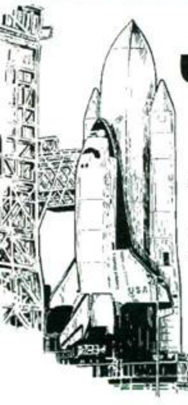

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Gallery of YOUNG

Stroll through our mini museum — the prize-winning essays and artwork of our youngest readers are on display.

Compiled by Jeanette Brown

Heralding from Hawaii, Hong Kong, Houston, and everywhere in between, the responses we received when we invited our young readers to participate in our 25th anniversary essay and art competitions were astounding — in their breadth and diversity as well as in the talent and knowledge they showcased. As the entries piled up, from houses and high schools alike, we got to read poetry and prose on topics ranging from the fate of the universe to future colonization of the moon and Mars. We got fanciful fiction, scholarly research, and autobiographical accounts. And the artwork — masterpieces in pencil, pen, paint, and photography — arrived on cardboard, construction paper, computer disks, and canvas. We've picked some of the best (not an easy task) and put them on display. Thanks to everyone who took part and special thanks to the teachers and parents who provide our next generation of astronomers with continuous encouragement.

STARS

FIRST PLACE (12–16 Age Group); Charlie Hall, Age 12; Eureka, Missouri

BiG KiDS

FIRST PLACE

My Greatest Observing Experience

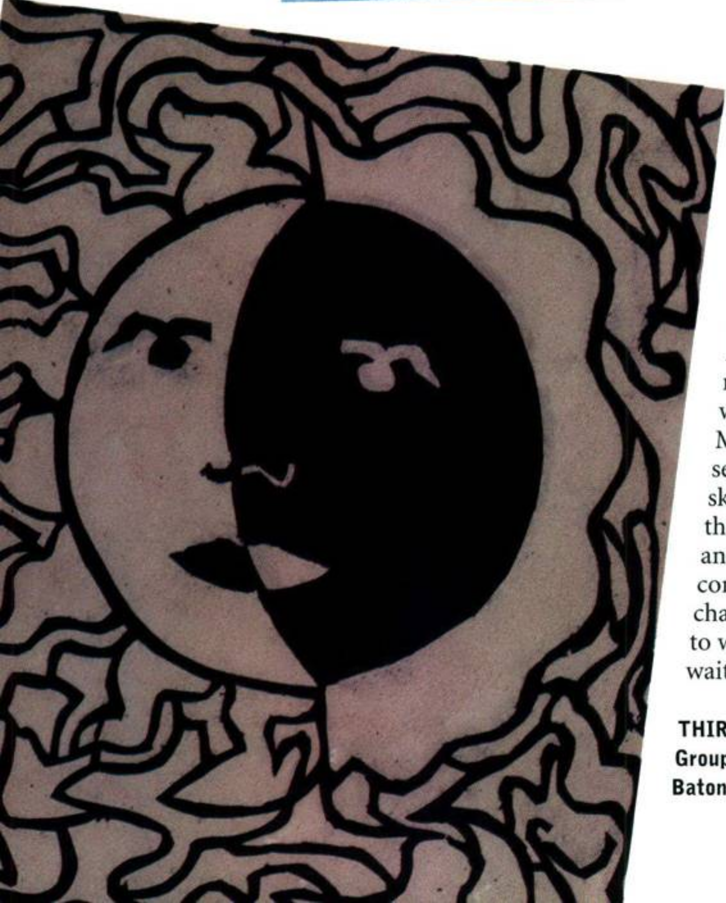
by Tiffany Wallis,
Austin, Texas, age 16

My greatest observing experience was my first, when I was no more than nine or ten years old. My dad owned a rusty, old 3-inch telescope that had collected dust in our attic for several years. Until he casually mentioned it one night, I had no idea he even owned one. At that age, I'd never really looked up at the stars with more than a vague, uncentered feeling of awe, but that one night my father opened up a new world for me.

My father knew nothing of astronomy either, nor did he really know anything about his own telescope. But that week he read somewhere that Saturn was bright, high in the sky, and easy to find. So, on a whim, he decided to dig out the old telescope. We live in the middle of a relatively bright city, and, in addition to that light pollution, the sky above our neighborhood is obscured by the many tall trees that surround the houses. Our narrow view of the sky only included a few constellations directly above our driveway.

Nevertheless, my father invited the family outside and we watched in silent fascination as he set everything up on the paved driveway. We spotted above us what looked like a bright star, called it Saturn, and pointed the telescope in its direction. My father adjusted the eyepieces and mounting until he had the object in view and then announced with plain disappointment that the star

SECOND PLACE (12–16 Age Group); Katie Mcarthy; Worcester, Massachusetts



THIRD PLACE (12–16 Age Group); Aimee Duke, Age 15; Baton Rouge, Louisiana

in question was not in fact our neighboring planet.

We picked another star and repeated the process, my father kneeling on the ground before us, humbled by the vast expanse of space above. Another disappointment followed, but we weren't ready to give up. My older brother and I set our young eyes to the sky, determined to spot the elusive Saturn. Had any of us known any constellations, had any star charts, or had any hint as to where in the sky Saturn waited, our search would have been much easier. We had, however, only our untrained eyes and some luck.

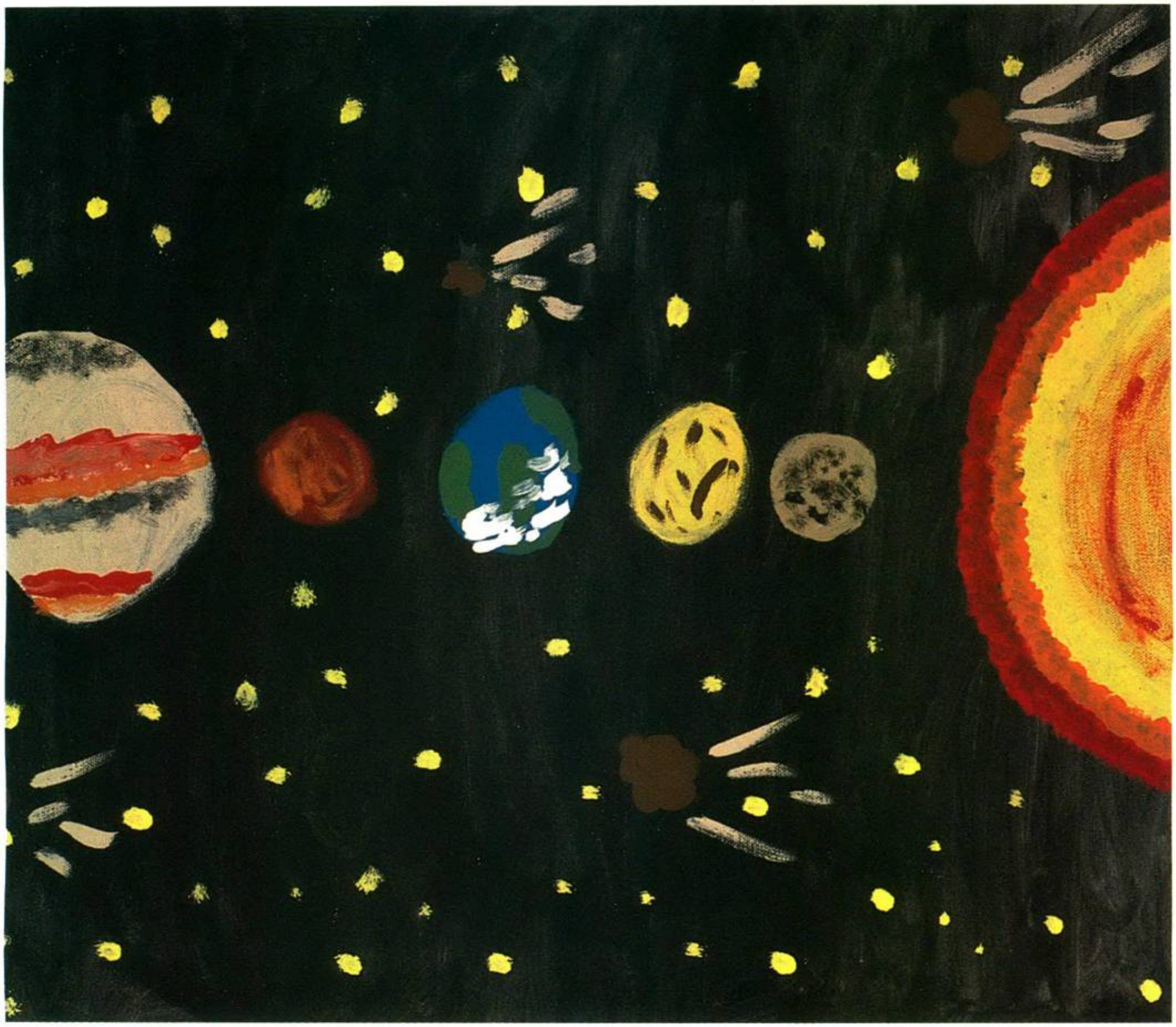
A few stars into the search, our efforts were richly rewarded. My father, squinting into the scope, squatting on the ground, proclaimed that he had found the ringed planet. I'm not sure what I expected to see as I approached the scope — perhaps a golden circle, but perhaps nothing more than a bright dot. I waited my turn to look, watching the sky and my father as he readjusted the scope to follow the planet as it traveled through the night. I was, as ten year olds often are, impressed with my dad's seemingly endless knowledge of the universe. It seemed to me that he could do anything — even find a planet.

As I approached the scope I felt the mounting excitement, the eager anticipation that comes before opening presents on birthdays or Christmas but that often leads to disappointment. In this case though, the distant ringed planet astounded me when I finally lay my eyes on it — I was not at all disappointed.

I could see Saturn's rings. There it was, right in front of me, a golden sphere with a set of magnificent rings encircling it. Though the planet was probably very small and blurry in the dusty telescope, it seemed huge to me. That I could see the rings of a planet millions of miles away seemed incredible. It boggled the ten-year-old mind. I couldn't take my eyes off of it.

I had to let my father readjust the scope, and I had to let the rest of my family take their turns, but as soon as everyone had looked I was in line for a second look. And then a third, and then a fourth. I stared in amazement until my mother dragged me back into the house and to bed.

To any experienced observer, Saturn is a familiar sight, and twenty minutes of searching for and then finally viewing Saturn through a rusty old 3-inch scope would probably not qualify as a great observing experience. To me, however, the night was incredible, and I'll always remember it that way. My father revealed to me the wonders of the universe that night. Though it wasn't until a few years later that I really got interested in astronomy, though it's only now that I've joined my high school astronomy club, and though I've only gone out observing a few times, that night started it all. I will always remember it as my greatest observing experience.



FIRST PLACE (6–12 Age Group); Rachel Whitley, Age 10; Baton Rouge, Louisiana

BiG KiDS

RUNNER-UP

Can One Believe Simulatneously in God and the Big Bang?

by Laurie Shaw,
Dunblane, Scotland, age 16

The Big Bang and God have an obvious link: One was the moment of creation and the other is an omnipotent creator. The fundamental question, however, is whether (with regard to modern-day science) belief in the two is consistent. One feature of our universe is that in order to allow life to evolve, the fundamental numbers (such as g, the gravitational constant) needed to be set within a very small range. Likewise, when we look around us we see that, for some unknown reason, the distribution of mass is equal and similar in every direction with just enough variation to allow large-scale structures (i.e. galaxies) to form. It has therefore become obvious that the initial conditions of the Big Bang, in order to allow life, had to be extremely precise. Is this then evidence of a supernatural creator, with the power to finely choose the initial conditions so that the universe would contain life?

Through the course of history scientists have grown to believe that events do not happen in an arbitrary fashion and that for every phenomenon there is a plausible explanation. Therefore, scientists have looked for different ways in which our universe could have developed so that the chances of life appearing would become a lot higher. One such idea is inflation, which is able to solve the matter distribution problems that required initial conditions to be so precise. Inflation, however, does not account for the actual moment of creation. Could God still have had a role to play after all?

Not if the "no boundary" proposal is correct. The no boundary proposal suggests that the universe is finite in extent but has no boundaries in either space or time. The surface of Earth is similar in that it is finite in extent (the circumference has a real, numeric value) but contains no barriers or edges (you can't fall off the edge of the world). The universe would be the same but in four dimensions, expanding and collapsing continuously. It would be completely self contained. What place now for a divine creator?

The no boundary proposal does, however, assume that our universe will eventually recollapse. If we discover that it will continue expanding forever, it would suggest that the universe was an on/off event, increasing the likelihood that there was originally supernatural intervention. It appears, therefore, that learning the fate of our universe would have tremendous bearing on whether we can have a place for God in our explanation of the universe's origin. Until we attain such knowledge, we cannot discard the notion that God may have set the initial conditions of the Big Bang (possibly so life could occur). Hence, one can conceive of circumstances in which the Big Bang and God are compatible. My own view is that we will never have a final and complete understanding of the creation, so there will always be room for a God.

SECOND PLACE (6–12 Age Group); Alice Guillermier, Age 4; Guadeloupe, Leeward Islands

LiTTLE KiDS

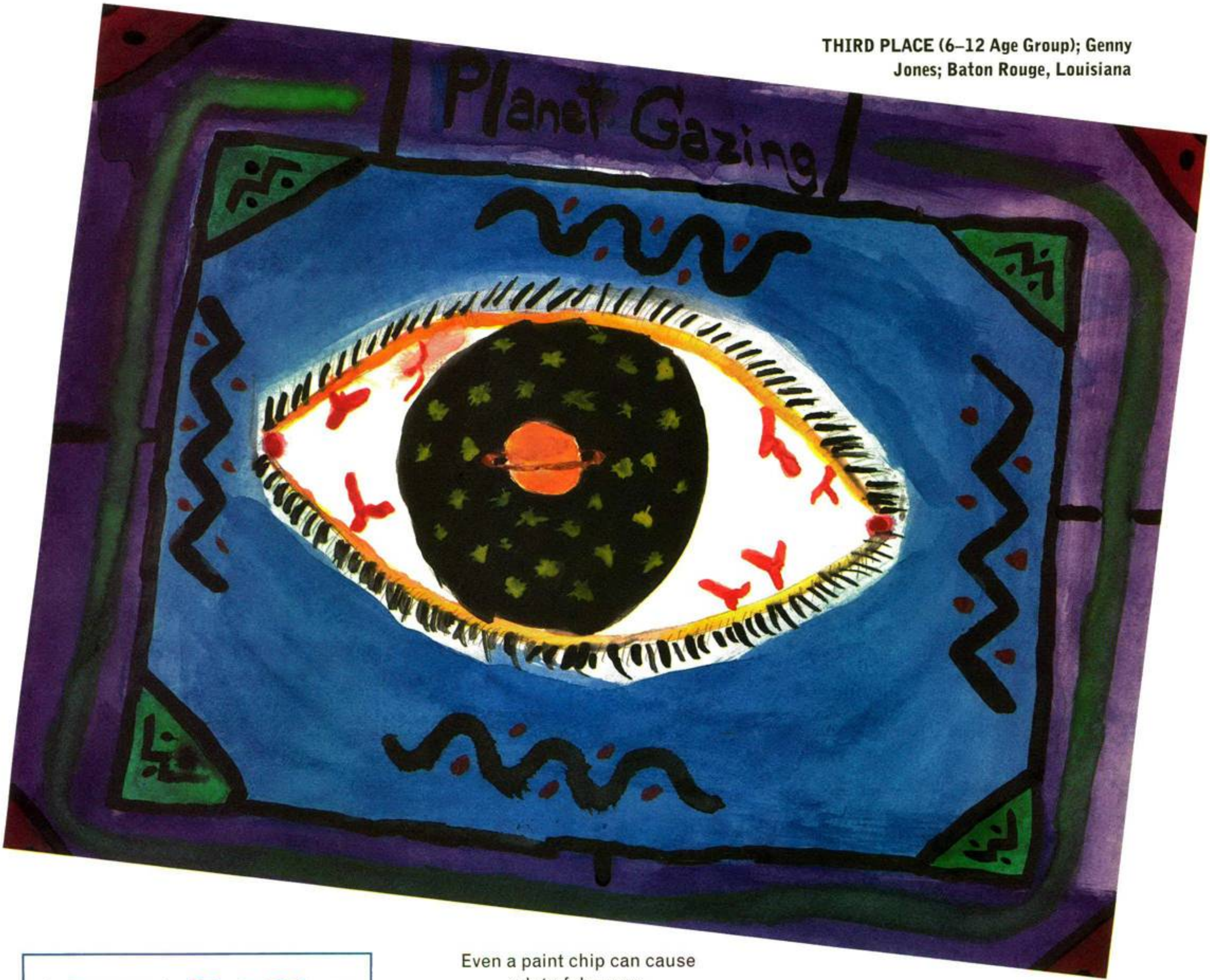
FIRST PLACE

Remembering Hale-Bopp

by Rebecca Kane, Lee, New Hampshire, age 9

One morning last spring at about four o'clock, my mom dragged me out of my warm, cozy, and very soft bed to look at a little fuzzy ball of light in the dark sky. It was Comet Hale-Bopp getting nearer to Earth on its long trip around the galaxy. The next time I saw it was a week later on an airplane going to France to visit my relatives. I looked out the window. I didn't notice it at first. Then my mom pointed it out to me. It looked like a star with little lines coming out of it. It was fuzzy around the edges, but it was more clear than last time. I had been studying about comets, and we learned that comets are made of ice. Some scientists think that Earth got its water from a comet crashing into it and melting. We also learned that anybody can have a comet named after them if they find it and report it. I certainly wish I had discovered Hale-Bopp.

Since I was studying comets, those sitings were exciting for me, but the best view was over the cliffs of Etretat in Normandy. Hale-Bopp was right in the middle of the sky, and this time I didn't need it to be pointed out to me. I thought it looked like a white hummingbird frozen in position. The cliffs are all chalk and they were lit up by lights pointed at them from the shore. They looked like big orchids for the hummingbirds to drink the nectar from in between their white petals. Hale-Bopp was so clear and not fuzzy at all that it almost looked blue. Between the white cliffs, the beach was covered with thousands of small round rocks like little eggs. The ocean was greenish black and looked very cold, even though the air was mild. It was one of the most amazing and beautiful sights I have ever seen. Comets used to be thought of as signals of bad luck. However, I think that I was very lucky to see Hale-Bopp in such a beautiful place.



THIRD PLACE (6–12 Age Group); Genny Jones; Baton Rouge, Louisiana

LITTLE KIDS
RUNNER-UP
What is the consequence of leaving our spacecraft debris in space?

by Whitney Porter,
Spokane, Washington

The junk that floats around
in space as debris,
Is like the flotsam and jetsam
adrift out at sea.

Except that this stuff goes
a lot faster
And can cause a lot of damage
and chance of disaster.

Even a paint chip can cause
a lot of damage,
That's why this problem is
so hard to manage.

While orbiting the Earth at
thousands of miles per hour,
This junk causes astronauts
to duck and cower.

All of this stuff held in orbit
by gravity,
Is a cause of concern for
potential tragedy.

Old satellite parts and
used rocket bodies,
Even the glove of Ed White are
now heavenly bodies.

If something made contact
with a space station,
It would cause compartment
decompression with the junk's
penetration.

The astronauts on board could
no longer last,
Their death would occur
relatively fast.

NASA has decided to make the
Space Shuttle tougher,
With reinforced tiles and other
kinds of buffers.

Maybe we could use a giant net
and a magnetic reactor,
And put all the junk in a giant
space trash compactor.

Then attach a rocket engine and
out of orbit it would go,
And so the chance of "junk collision"
would be relatively low. ▣

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- The totally cordless electronics have a built-in drive corrector which is activated when using the optional hand control. The R.A. motor's main tracking speed is an accurately regulated sidereal rate. The optional hand control allows for fast and slow override of R.A. tracking speed and ± operation of the optional DEC motor. A comment from the *Sky & Telescope* review — "the digital electronics delivered a near-perfect sidereal tracking rate."
- The Celestar 8 is powered by a 9 volt alkaline battery.
- The Celestar 8 drive can operate in the Northern or Southern hemisphere from 0° to 90°.
- The new and unique Wedgpod is a combination tripod and wedge. It has a fixed height (33") and is lightweight without compromising its stability.
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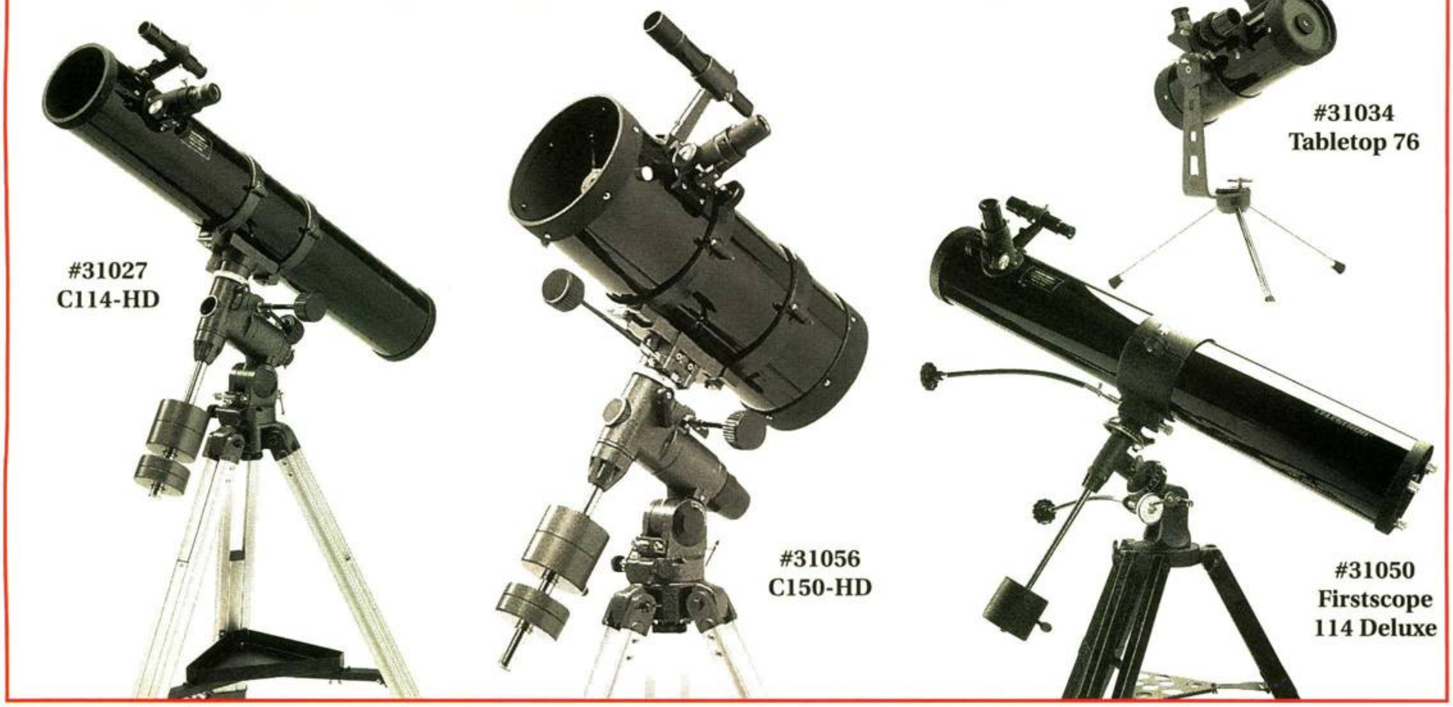

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The 114mm (4.5") Newtonian equatorial telescope is the most popular size telescope for the more serious beginning or intermediate level astronomy enthusiast, and for good reason. The large light gathering power of this 4½" telescope makes it ideal for deep-sky observation of galaxies, star clusters and nebulae, as well as lunar and planetary observing. This makes for a very useful and versatile instrument that can take an observer from the very first time looking through a telescope's eyepiece, through years of observing interesting subjects near and far in the night sky.

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The Firstscope 114 series has four models. Each is a high quality, economical telescope with a superb optical system housed in a glossy black metal tube. The equatorial mount is quite stable, with setting circles and slow motion controls on both axes for easy, smooth tracking. Strict adherence to Celestron's tough quality standards for manufacturing, assembly and testing ensures that each telescope performs well.

The C114-HD attaches to the CG-4 mount, a very rigid German equatorial mount designed for the discriminating buyer. This heavy duty 114mm Newtonian stands out from the other 114mm telescopes on the market by having by far the best mount.

The C150-HD is a 6" Newtonian telescope which uses the CG-4 mount. This telescope was engineered for the more serious astronomer who wants not only a very rigid mount but also a larger aperture. The premium optics of this heavy duty telescope are manufactured to Celestron's uncompromising standards. The star images are classic textbook airy disks.

The C150-HD offers views of intriguing lunar details and high power planetary viewing. You can see detail in Jupiter's equatorial belts, the beautiful ring structure of Saturn and the polar caps of Mars. This telescopes is large enough to observe hundreds of deep-sky objects with ease, fully resolve many globular star clusters, and allow you to enjoy viewing brighter nebulae, double stars and galaxies.

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THE SKY SHOW

The giant planets return to prime observing positions as Jupiter approaches opposition with Saturn at its heels. Take time to enjoy the festoons, rings, and cloud bands these planets have to offer. By Martin Ratcliffe and Alister Ling

▶ August opens with a waxing moon brightening the landscape as soon as night falls. On August 1 it lies in Libra. It then passes through the summer zodiac as it grows to full by August 7. The so-called Green Corn moon dips into the outer penumbral edge of Earth's shadow on this night, but at mid-eclipse (10:25 p.m. EDT) less than one-eighth of the moon's diameter is in partial shadow. The slight dimming will be impossible to detect visually. A series of CCD images of the moon might be able to register an intensity change over the period of the eclipse, but it would have to be measured using a computer program.

By August 10, the moon rises with **Jupiter** at around 10:20 p.m. local time. For the following three nights, the moon will interfere with the best of the Perseid meteor shower. The Perseids are one of the finest showers of the year, and their reputation guarantees rewards for the patient observer. A few brilliant shooting stars should be seen during maximum on August 12.

Jupiter is just one month away from opposition and already dominates the eastern half of the sky glowing at a brilliant magnitude –2.8 by mid-August. The apparent size of the mighty planet reaches 48.8" by the end of the month, just one arcsecond shy of its maximum at opposition. With the warm evenings, August is a splendid time to begin a series of drawings of the jovian atmosphere. Decked with dark belts, white spots, and the famous great Red Spot, the planet could perhaps be called the "star attraction" for the month.

Rising on Jupiter's heels, about 80 minutes later, is another major planet, **Saturn.** It reaches its stationary point on August 16

A rising or setting full moon is always a beautiful sight. The Robert Moses bridge, which connects Long Island to Fire Island in New York, serves as a backdrop to this double exposure photograph.

Larry Landolfi

AUGUST 1998

3 Uranus is at opposition, 3 a.m. EDT (page 88)

4 Venus passes 0.8° south of Mars, 11 p.m. EDT (page 89)

6 The moon passes 2° north of Neptune, 9 p.m. EDT

7 The moon passes 3° north of Uranus, 3 p.m. EDT
Full moon is at 10:10 p.m. EDT; penumbral lunar eclipse

8 Venus passes 7° south of Pollux, 2 p.m. EDT

10 The moon passes 0.9° south of Jupiter, 8 p.m. EDT

11 The moon is at perigee (227,699 miles from Earth), 7:47 a.m. EDT
Mars passes 6° south of Pollux, 5 p.m. EDT

12 Perseid meteor shower peaks (page 86)

13 The moon passes 2° south of Saturn, 8 a.m. EDT
Mercury is in inferior conjunction, 8 p.m. EDT

14 Last quarter moon is at 3:48 p.m. EDT

15 The moon passes 0.2° north of Aldebaran, 11 p.m. EDT

16 Saturn is stationary, noon EDT

19 The moon passes 4° south of Mars, 4 p.m. EDT

20 The moon passes 3° south of Venus, 10 a.m. EDT

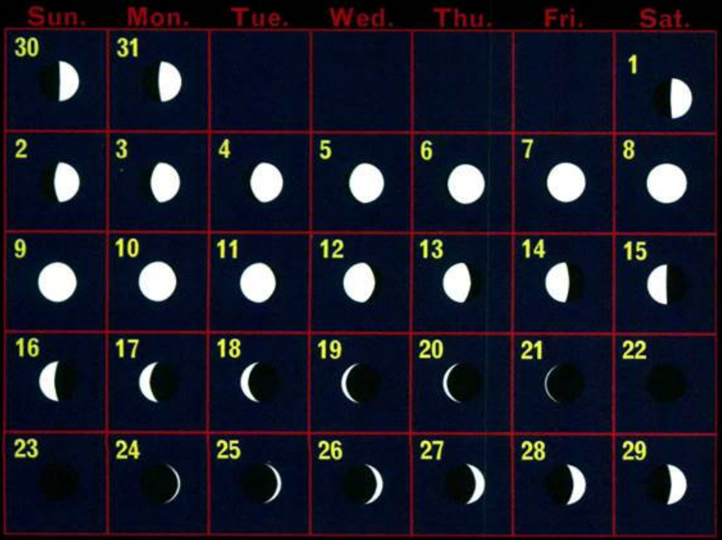
21 New moon is at 10:03 p.m. EDT; annular solar eclipse

25 Mercury passes 3° south of Venus, 7 p.m. EDT

27 The moon is at apogee (251,747 miles from Earth), 2:26 a.m. EDT

30 First quarter moon is at 1:06 a.m. EDT

31 Mercury is at greatest western elongation (18°), 5 a.m. EDT (page 89)



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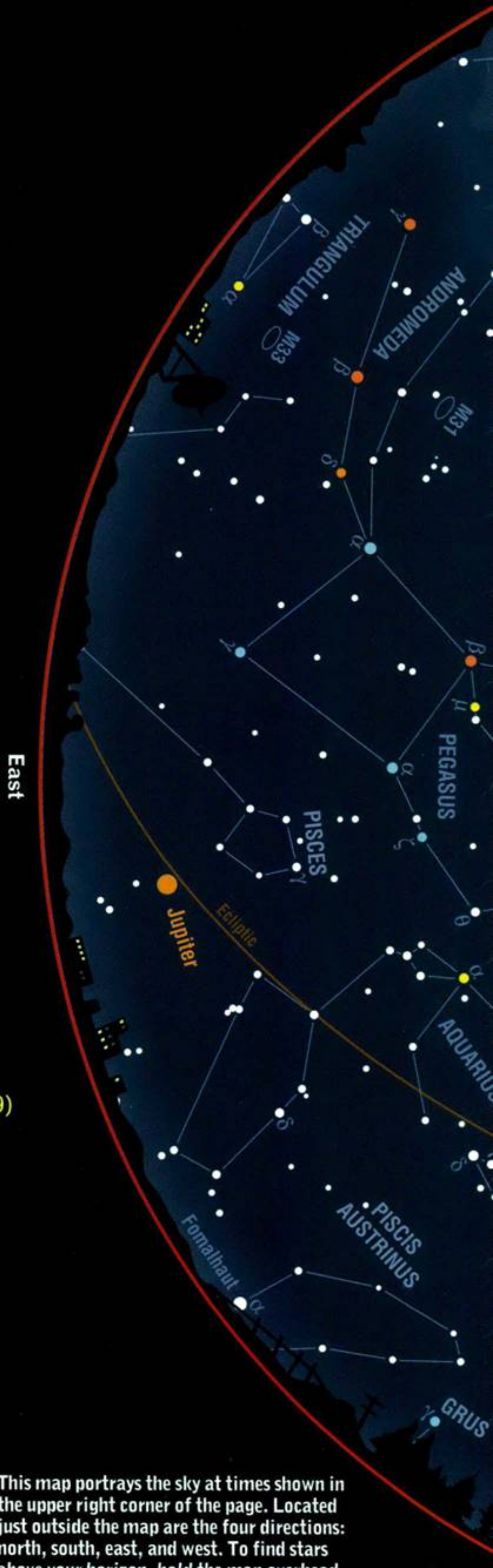
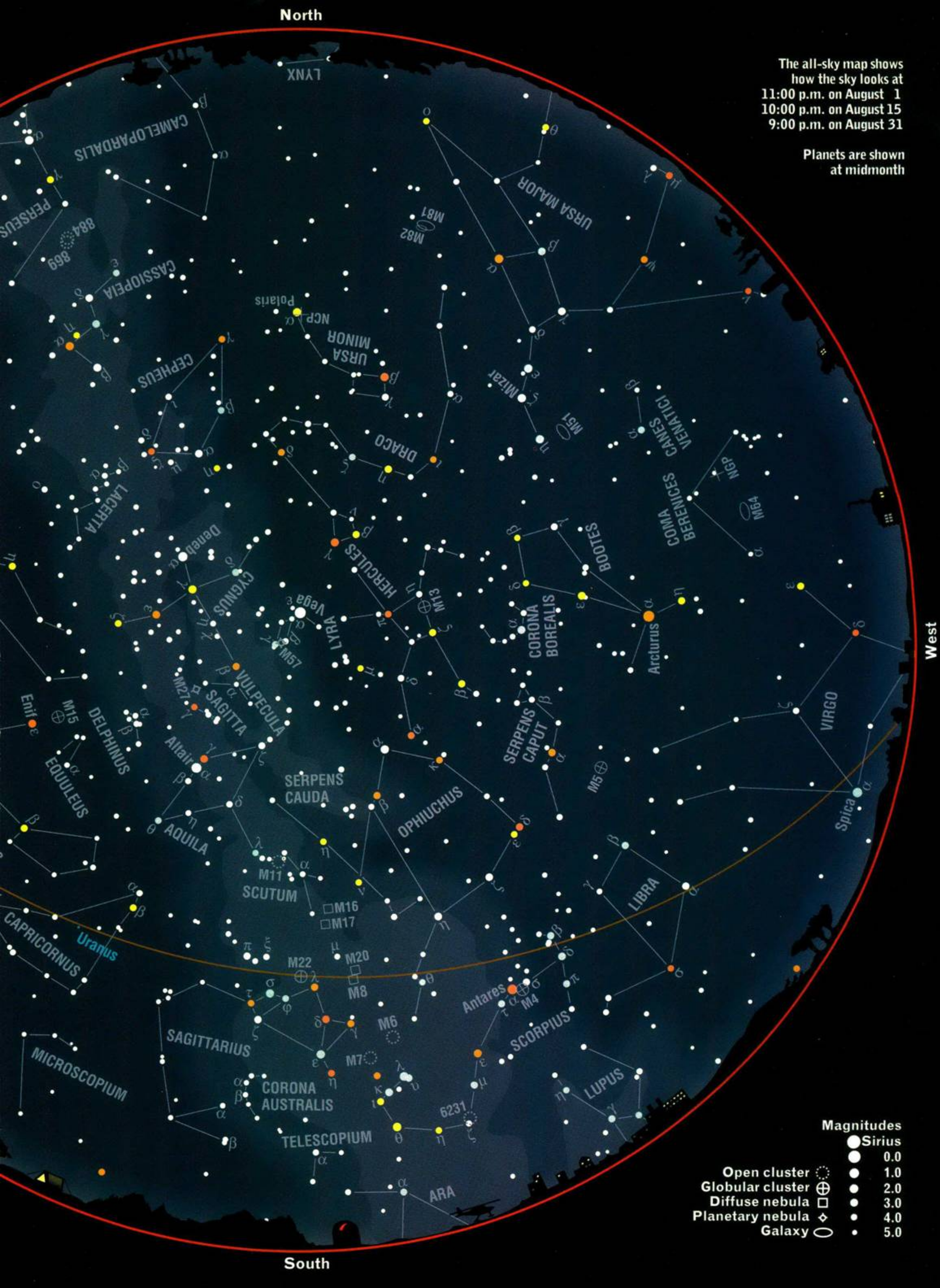


This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above *your horizon, hold the map overhead* and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.


North
LYNX
CAMELOPARDALIS
PERSEUS
884
869
CASSIOPEIA
Polaris
NCP
URSA MINOR
URSA MAJOR
M81
M82
CEPHEUS
DRACO
Mizar
M51
CANES VENATICI
LACERTA
Deneb
CYGNUS
HERCULES
COMA BERENICES
NGP
M64
BOOTES
Vega
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M57
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VULPECULA
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SAGITTA
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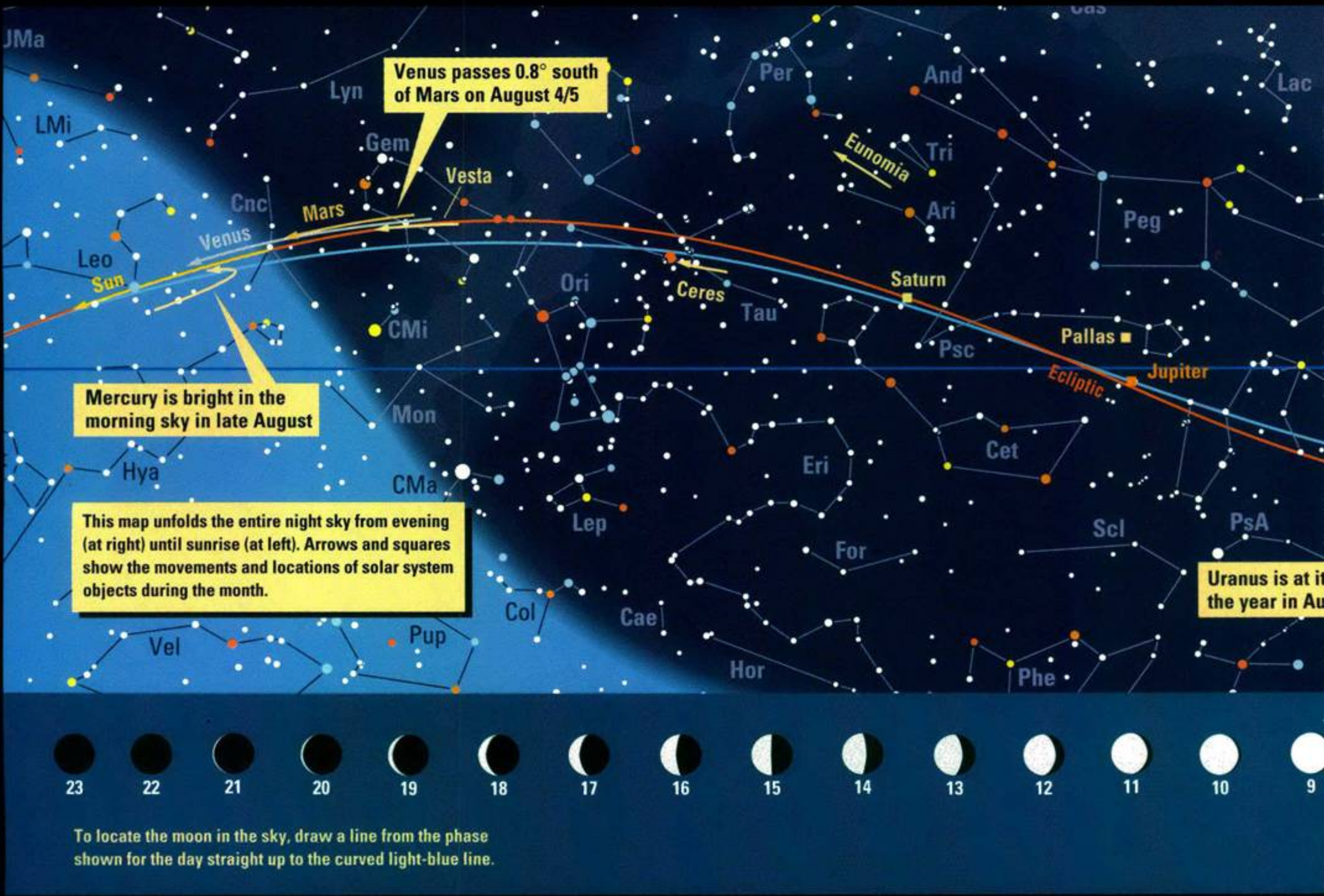
DELPHINUS
EQUULEUS
Altair
SERPENS CAPUT
M5
VIRGO
SERPENS CAUDA
OPHIUCHUS
AQUILA
Spica
M11
SCUTUM
LIBRA
M16
M17
CAPRICORNUS
Uranus
M22
M20
M8
Antares
M4
M6
SCORPIUS
SAGITTARIUS
M7
MICROSCOPIUM
CORONA AUSTRALIS
LUPUS
6231
TELESCOPIUM
ARA
South
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

The all-sky map shows
how the sky looks at
11:00 p.m. on August 1
10:00 p.m. on August 15
9:00 p.m. on August 31

Planets are shown
at midmonth

THE PATH OF THE PLANETS


JMa
LMi
Lyn
Gem
Cnc
Mars
Vesta
Venus
Leo
Sun
CMi
Mon
Hya
CMa
Vel
Pup
Col
Lep
Cae
Ori
Ceres
Tau
Per
And
Eunomia
Tri
Ari
Saturn
Psc
Pallas
Jupiter
Ecliptic
Cet
Eri
For
Hor
Scl
Phe
PsA
Peg
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17
16
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14
13
12
11
10
9

Venus passes 0.8° south of Mars on August 4/5

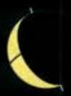
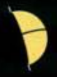
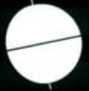
Mercury is bright in the morning sky in late August

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.

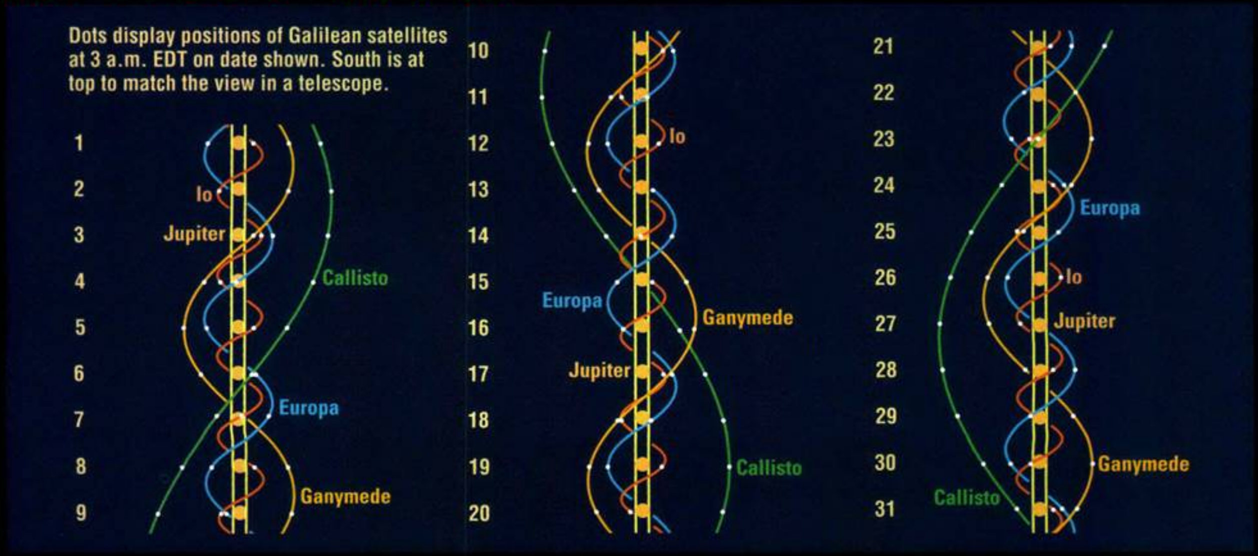
Uranus is at it
the year in Au

To locate the moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

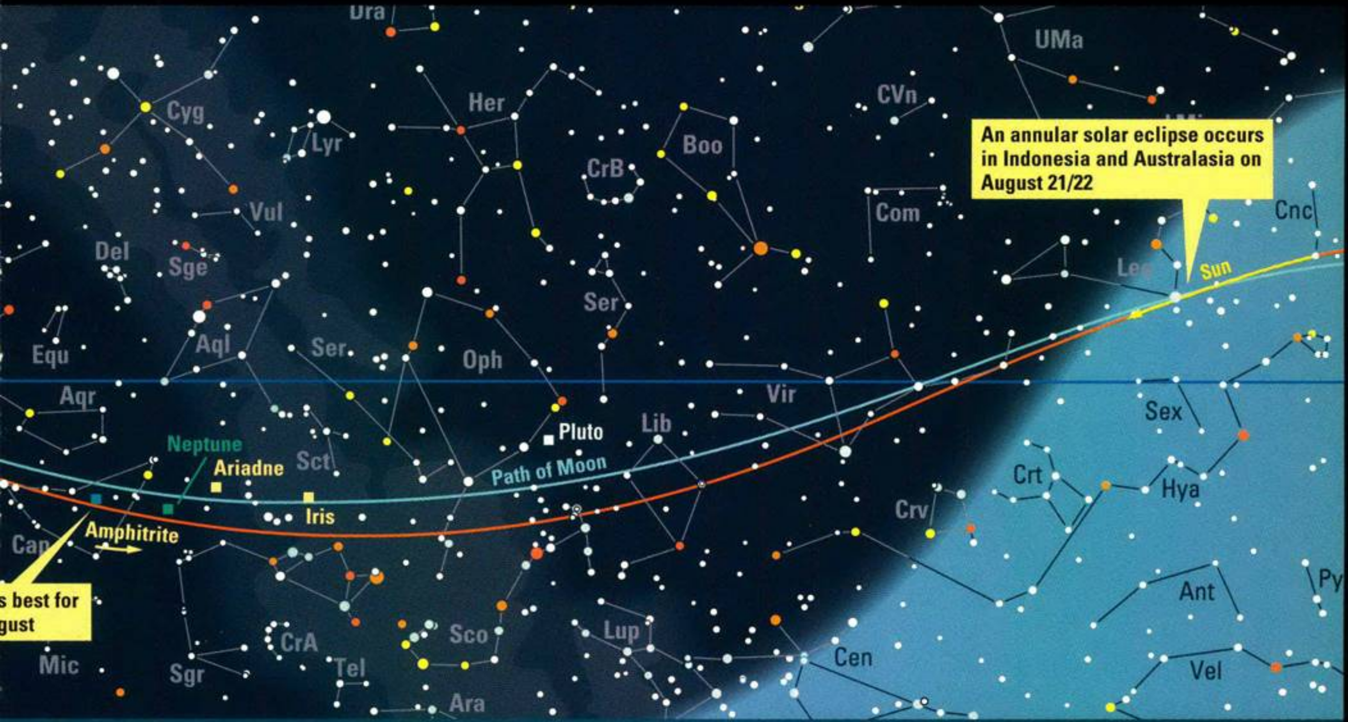
PLANETS	MERCURY	MERCURY	VENUS	MARS	JUPITER
Date	August 1	August 31	August 15	August 15	August 15
Magnitude	1.7	–0.1	–3.9	1.7	–2.8
Angular Size	10.3"	7.4"	10.5"	3.8"	48.0"
Illumination	17%	43%	94%	98%	100%
Distance (AU) from Earth	0.656	0.912	1.582	2.445	4.108
Distance (AU) from Sun	0.458	0.318	0.719	1.594	4.973
Right Ascension (2000.0)	9h56.3m	9h26.3m	8h17.4m	7h53.9m	23h50.7m
Declination (2000.0)	8°29'	14°44'	20°09'	21°49'	–2°37'

JUPITER'S MOONS



Dots display positions of Galilean satellites at 3 a.m. EDT on date shown. South is at top to match the view in a telescope.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Ser
Oph
Vir
Aqr
Pluto
Lib
Sex
Neptune
Ariadne
Sct
Path of Moon
Crt
Hya
Iris
Cap
Amphitrite
Crv
Ant
Py
Mic
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Lup
Cen
Vel
Sgr
Tel
Ara

An annular solar eclipse occurs in Indonesia and Australasia on August 21/22

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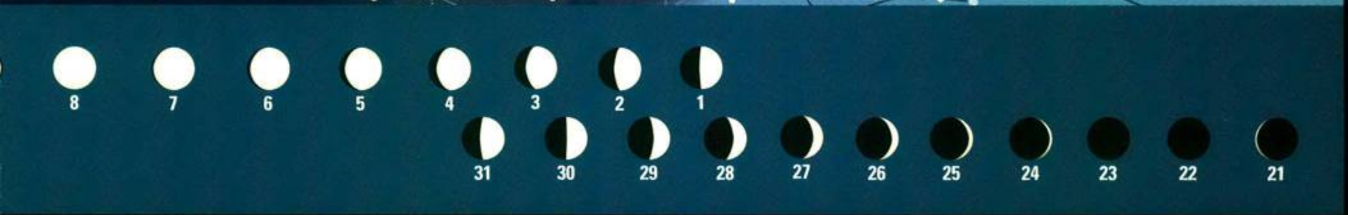
gust


8
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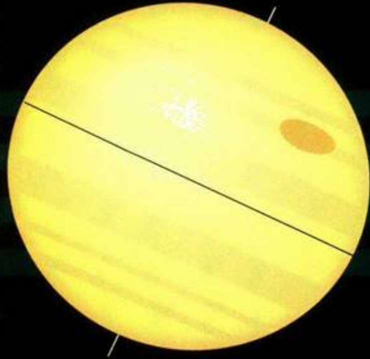
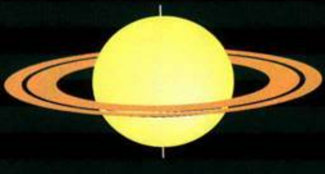
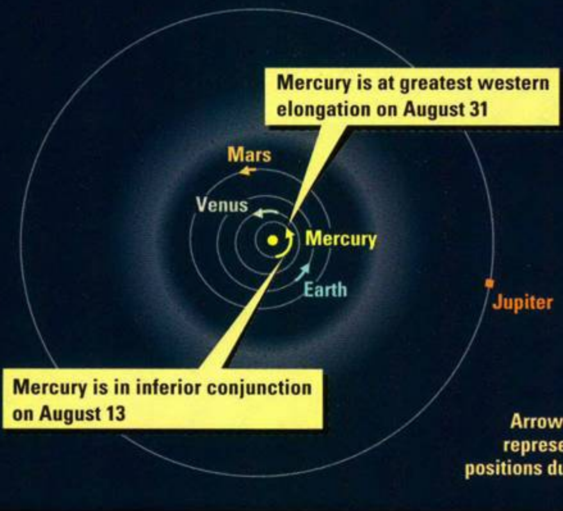




SATURN	URANUS	NEPTUNE	PLUTO
August 15	August 15	August 15	August 15
0.1	5.7	7.9	13.8
18.6"	3.7"	2.3"	0.1"
100%	100%	100%	100%
8.937	18.878	29.195	29.841
9.305	19.871	30.138	30.085
2h09.2m	20h51.8m	20h09.3m	16h22.2m
10°18'	–18°19'	–19°46'	–9°22'

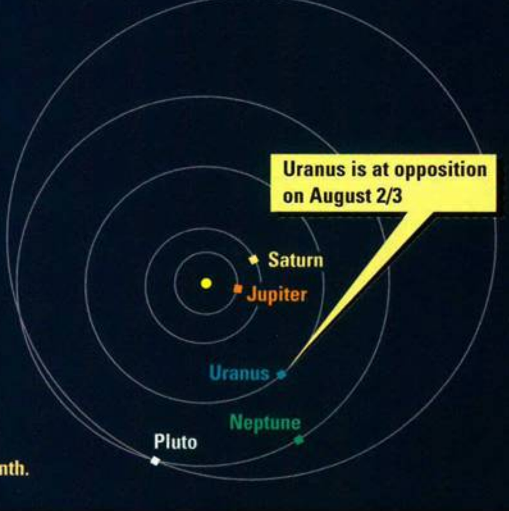
THE PLANETS IN THEIR ORBITS


Mars
Venus
Mercury
Earth
Jupiter

Mercury is at greatest western elongation on August 31

Mercury is in inferior conjunction on August 13

Arrows and dots represent planets' positions during the month.


Saturn
Jupiter
Uranus
Neptune
Pluto

Uranus is at opposition on August 2/3

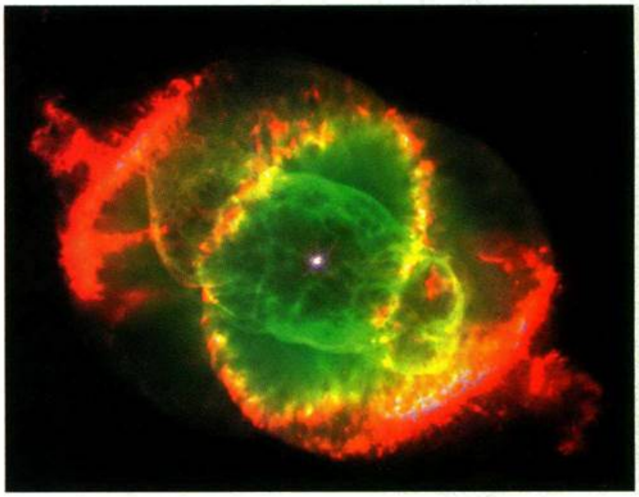
FIRST VIEW: The Cat's Eye Nebula

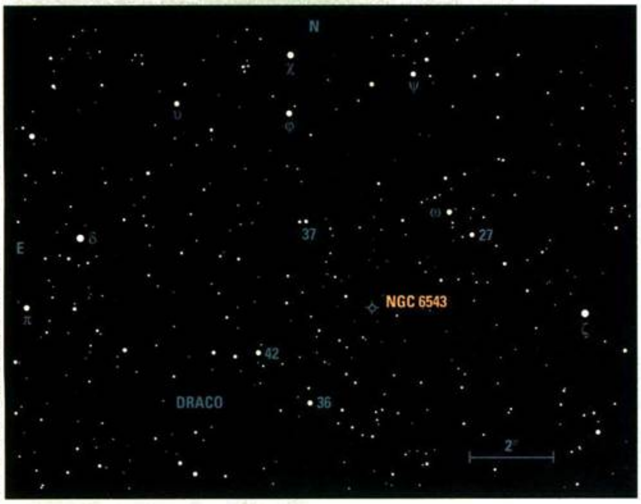
Tucked away in the coils of Draco is a gleaming emerald eye, the planetary nebula NGC 6543. Best known as the Cat's Eye Nebula, NGC 6543 is one of the highest surface brightness nebulae in our sky. It is so bright that when you look directly at it the nebula glows green.

William Herschel discovered this gem on February 15, 1785, with his polished tin-copper 18-inch reflector. Today's amateurs can see it from a city backyard with a 6-inch telescope.

Begin your search for NGC 6543 with the beautiful pair of stars that comprises Nu (ν) Draconis in the head of Draco high overhead. Then drop northward to a point midway between Zeta (ζ) and Delta (δ) Draconis. There you'll find your target, resting at 17h58.6m 66°38' (2000.0).

At low power, you'll quickly notice the nebula as it appears to be a peculiar soft-looking 9th-magnitude star.


NASA/STScI



All illustrations by *Astronomy*: Kelly Jaeger

Ronald Royer

Look right at it and the nebula's green color leaps out. The nebula's high surface brightness allows you to boost the power to high magnifications — as much as the atmosphere will allow. When you do, remember to take note of the slight elongation from north to south.

In bigger scopes, the Cat's Eye appears bright green and begins to display some texture. This detail led William Herschel to believe the gaseous cloud could be resolved into a cluster of stars. Even Lord Rosse with his 72-inch Leviathan could not detect a central star. Today, we can marvel at the incredible level of detail revealed by the Hubble Space Telescope.

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among the stars of Cetus the Sea Monster, a non-zodiacal constellation. Saturn's orbital inclination can carry it more than 2° away from the ecliptic and the constellations of the zodiac. Currently, Saturn's orbit causes the planet to remain in a tiny corner of Cetus all month. Look for the moon to glide south of the ringed planet on August 13.

Though Saturn's atmosphere doesn't quite carry the impact of Jupiter's, it does have its own unique attraction — its wonderful ring system. The rings add brilliance and size to the planet, and this month they span 42". Saturn's rings place the planet's overall apparent diameter close to that of Jupiter. Without the rings, Saturn's disk is a mere 17" across.

Saturn is slowly brightening toward its October 23 opposition. This month it manages a respectable magnitude 0. The planet is nearly as bright as the star Vega in the neat little constellation Lyra the Harp, which passes overhead on summer evenings.

Vega is one of seven bright stars visible after the sun sets and usually is the first star to cut through the twilight colors of the setting sun. At magnitude 0, it is the brightest of the three stars that make up the Summer Triangle. Altair in Aquila the Eagle comes in second place at magnitude 0.8, while Deneb in Cygnus the Swan gleams at magnitude 1.25.

Setting to the southwest, more than two hours after the sun, is magnitude 1.0 Spica in Virgo the Maiden. High above it and lingering over the western horizon until well past midnight is Arcturus at magnitude 0. Arcturus is the brightest star in the constellation Bootes the Herdsman. Similar to this orange tinted star is Antares in Scorpius the Scorpion. Can you tell if Antares is redder than Arcturus? Antares shines at the same magnitude as Spica — compare them before Spica sets. Does the color influence your perception of their brightness?

The seventh bright summer star is magnitude 1.2 Fomalhaut in Pisces Austrinus the Southern Fish. It appears over the southeastern horizon roughly 40 minutes after Jupiter.

Uranus is coincidentally at the same right ascension as Deneb. That means the two cross the local meridian at the same time — this month that moment occurs at midnight.

Your "local meridian" is an imaginary line that runs due north and south across the sky passing though a point directly overhead, known as the zenith. Everyone has a local meridian, since by definition it is based on the observer's location.

Stars, planets, and the sun rise to the east of the local meridian and set to the west of it. They reach their highest point in the sky when they lie exactly on the meridian. This event is called culmination. It also means that at culmination the star or planet is due south or north.

The Big Dipper and Little Dipper never set from many locations in the Northern Hemisphere. Because these stars appear to circle around the pole star, Polaris, they are called circumpolar groups of stars. Circumpolar stars have a lower and upper culmination that is separated by 12 hours.

We also get the terms *a.m.* and *p.m.* from the meridian. The sun's position plays a major role in how we tell time. Our star is before the meridian or ante meridiem (a.m.) in the morning and after or post meridiem (p.m.) in the evening.

Another term often used is ecliptic. The ecliptic is the apparent annual path the sun takes across the sky. This motion of the sun with respect to the stars is caused by Earth's yearly motion around the sun. As we orbit the sun, it appears to move through twelve different constellations.

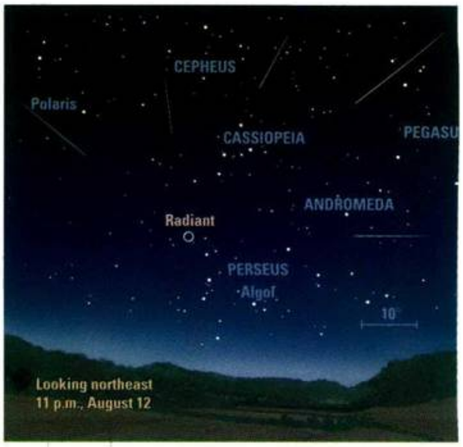
To find the planets, you must always look along the ecliptic. For Northern

Major Meteors

Perseid and M33. Chuck Vaughn

Nothing can drown out the mighty Perseid meteor shower — not even the bright waning moon. This most famous shower has rightfully earned its reputation with standard rates of 60 or more meteors per hour. Unfortunately, this year the moon will cut that number by at least half. As always, the best plan of action is to get out of the city to a clear, relatively pollution-free, dark site. Observing from brightly lit city skies tries the patience of all but the most determined, and the moon will furnish enough light to contend with.

This year, both the "new" and "traditional" peaks occur during daylight hours of August 12 — giving two nights of good observing. Many meteors should be seen on both the nights of August 11–12 and August 12–13. Traditional wisdom mandates waiting until after midnight for higher meteor rates, but with the moon out of the sky for the first few hours of the evening, you're likely to see more before midnight. So grab a few friends, pack up some warm clothes, chairs, a thermos of your favorite beverage, and enjoy the night.

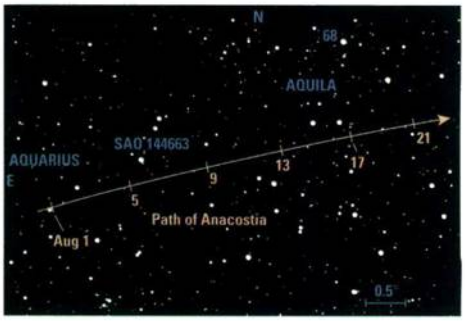


Looking northeast
11 p.m., August 12

Asteroid Challenge

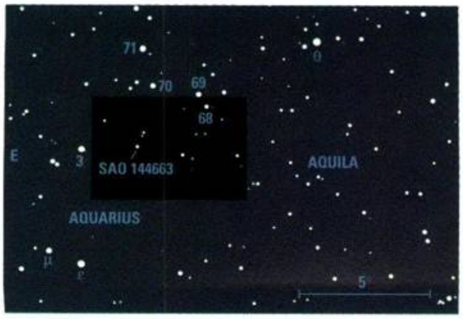
Most of the asteroids we present in these boxes are among the first 100, because they're the brightest. This month brings a chance to spot a higher numbered rock, 980 Anacostia.

Anacostia was discovered by G. H. Peters in 1921. Granted, at magnitude 10.7 it's a little tougher than our usual targets, but it's still within the limits of an 8-inch telescope.



Why is Anacostia so bright? To begin with, it's a medium sized asteroid — roughly 90 km (55 miles) in diameter. More importantly, is Anacostia's position relative to Earth. The asteroid is approaching perihelion (closest point to the sun), while Earth is at aphelion (farthest point from the sun). This brings the twosome about as close as they can get.

To find Anacostia, start at Theta (θ) Aquilae (the left wingtip star of the Eagle) and slide 6° eastward to 69 and 70 Aquilae, then drop 2° south. The scale of the finder chart given here plots stars as faint as magnitude 11.5, well within the magnitude range for Anacostia.



Jupiter Rules the Evening

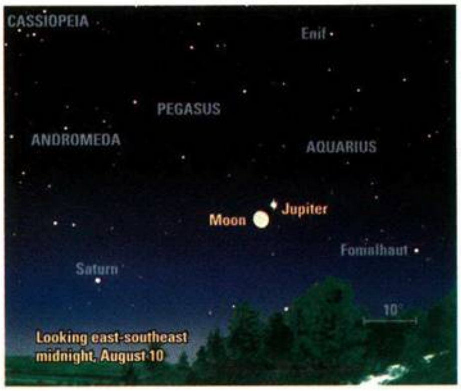
STScI/JPL/NASA

You can't miss Jupiter as its pale peach beacon rises in the east while dusk turns into night. The planet always offers a surprise — sometimes it's the great Red Spot, other times it's the complex swirls and festoons in the equatorial belts. Perhaps a neat arrangement of the Galilean moons will pique your interest, or a shadow or two on the silent cloud tops.

Jupiter's details become easier to see as the evening progresses and the planet rises higher in our sky. When an object's altitude is low, its light passes through a greater thickness of Earth's atmosphere before it reaches our eyes. As that object rises higher in the sky, its light goes through less of Earth's atmosphere so the planet is less likely to appear distorted by atmospheric turbulence. This is the reason why stars twinkle, especially when they are close to the horizon. The best place to look at an object is at the zenith (the point 90° above the horizon or straight up).

Once the planet is at a decent altitude, try to identify its moons — use the Path of the Planets section on page 65 as your guide. Find Europa and remember that life could possibly be living in an ocean beneath the icy, cracked surface.

Jupiter finds itself a couple of diameters above the bright disk of the moon, just three days past full, on August 11. Lucky observers in the eastern half of the continent can witness a double shadow transit on August 22–23. The event starts at 10:20 p.m. EDT. For one hour and twenty minutes, Io's shadow will chase the smaller and tougher dark dot of Callisto's shadow. By 11:00 p.m., try to spot Io crossing in front of Jupiter's disk.



Saturn Enters the Late Night Sidewalk Zone

After several months in the morning sky, Saturn bursts onto the scene for the late movie and theater crowd. August is an ideal time to treat the public to some sidewalk astronomy, and no object better draws the sounds of delight from people than the ringed marvel Saturn.

This planet's majestic ring system has opened up past 16° — even the uninitiated will have little trouble spotting the Cassini division in an 8-inch scope. Don't forget to check out the shadow cast by the cloud tops on the rings. The image is so startlingly real that people often think it's some kind of trick.

If the night air is steady, you can boost the power to seek out the planet's moons. Titan is the brightest at magnitude 8.4. Rhea is next at magnitude 9.7. Tethys and Dione follow at magnitude 10.4, and the half-dark moon Iapetus comes in at magnitude 11.0 — though it could be fainter if on the eastern side of Saturn. You'll need greater than a 10-inch scope if you want to see Mimas — the innermost satellite of this main group. Saturn's other satellites are too faint to be seen in sidewalk scopes.

Phillippe Durville

Hemisphere observers, the ecliptic passes through the southern half of the sky, so the planets always appear to be in the southern part of the sky and can never appear in the north.

When a planet reaches opposition, it is opposite the sun in our sky. The view of our solar system from above would show the planet, Earth, and sun in a straight line. The sun would be on one side of Earth, with the planet at the opposite end on the other side of Earth. Since a planet at opposition is always opposite the sun in our sky, it rises as the sun sets and sets as the sun rises. Such a planet is visible nearly all night and will be at its highest point in our sky at midnight.

Prior to opposition the planet reaches the meridian after midnight and is referred to as a morning object. After opposition the planet is called an evening object and reaches culmination before midnight. The best time to observe a planet is during its time of opposition, but only superior planets (those farther from the sun than Earth) can reach opposition. Neither **Mercury** nor **Venus**, the two inferior planets, can appear opposite the sun in our sky.

On August 3 Uranus reaches opposition. Uranus was the first planet to be discovered using a telescope. This important discovery was made in 1781 by British amateur astronomer William Herschel, who was subsequently knighted for his achievement. Uranus is a large planet, about five times larger than Earth, but it never comes closer to us than 1.75 billion miles. It takes light, traveling at 186,000 miles per second,

OBSERVER'S CHALLENGE: Uranian Moons

NASA/JPL

Step forward, eagle-eyed observers and Shakespeare fans — you don't need brute aperture to peg the four brightest moons of Uranus. The only requirements are steady skies, patience, and at least a 10-inch scope.

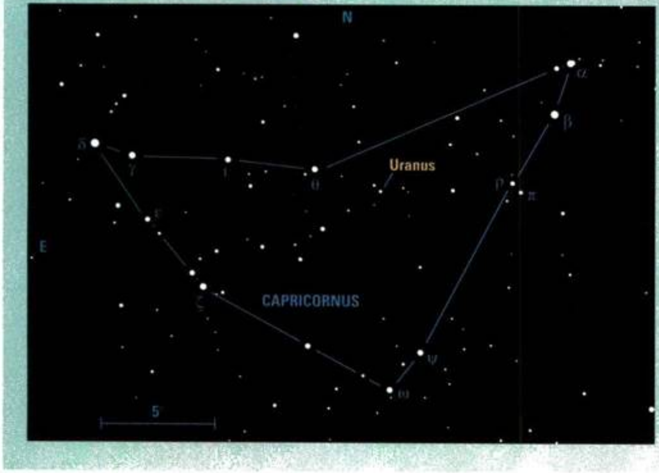
The moons are bit fainter than Pluto, but 5.6-magnitude Uranus lies smack in the middle of the field. To help cut down the glare, try placing an occulting bar in a high powered eyepiece. If your eyepiece has an accessible field stop (a sharp lip tucked inside the barrel), place a card or piece of foil there to cover one-third of the field. Then, while observing, place Uranus behind it. You're going to need a drive as well — following a moving target without one may give you a headache.

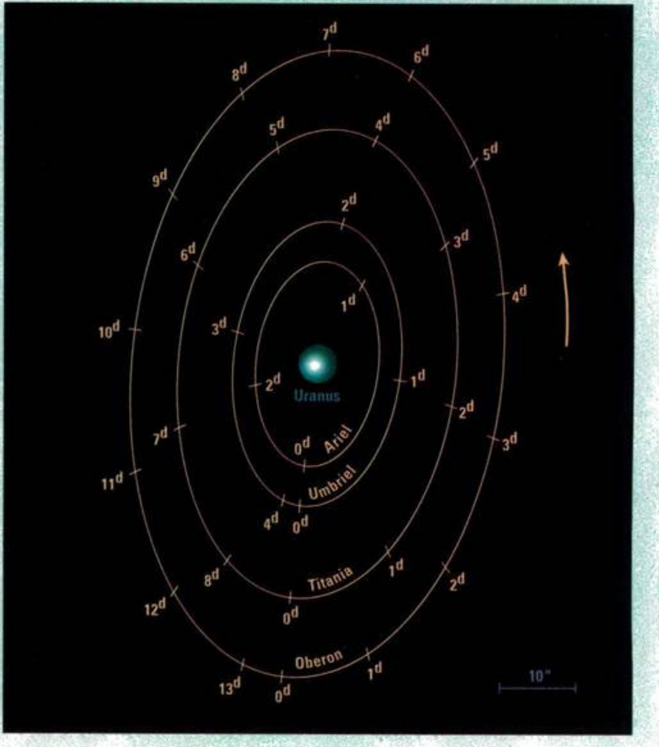
Titania, at magnitude 13, is the brightest of these Shakespearian-named moons. It is followed by Oberon (14.1), Ariel (14.4), and Umbriel (15.1). Earth's moon at that distance would be slightly brighter. As you observe these moons, think about their sizes and distances. The moons of Uranus range from 1,200 to 1,600 km in diameter (750 to 1,000 miles) and lie almost 3 billion km (1.75 billion miles) away.

Uranus is at opposition on August 3, so it rises at sunset. By 10 p.m., the planet will be reasonably well placed at the top center of Capricornus — about 3° west of Theta (θ) Capricorni. Its disk is a mere 3.7" across.

To help you figure out which moons you are seeing, use the diagram below. Each moon's point of greatest northern elongation is marked by day 0. The successive days in each orbit are also marked. With this diagram and the times listed below, you can calculate the position of any moon on any given day. Remember, Titania is the brightest and never more than 30" away from Uranus.

Oberon has its greatest northern elongation on July 29 at 9:48 a.m. (EDT). Its orbital period is 13d 11.1h, so Oberon's next passage through this point will be on August 11. Titania is at this point on August 1 at 9:30 a.m. (EDT), and its orbital period is 8d 16.9h. For Umbriel this occurs at 7:06 p.m. (EDT) on August 3. Umbriel has an orbital period of 4d 3.5h. Lastly, there is speedy Ariel. It passes greatest northern elongation on August 2 at 12:12 a.m. (EDT), and its orbital period is 2d 12.5h.





two hours and 36 minutes to travel that distance. Consequently, Uranus never appears larger than a mere 3.7" (about 1/500 the apparent diameter of the full moon) in earthbound telescopes. The planet does attain a magnitude of 5.7 this month. When Uranus is that bright, the unaided eye can detect it on a perfectly clear, dark night away from streetlights — though a trusty 6th-magnitude star atlas should be consulted closely. Uranus can be found near the magnitude 5.9 star 19 Capricorni. The planet appears distinctly green when compared to the reddish 19 Capricorni.

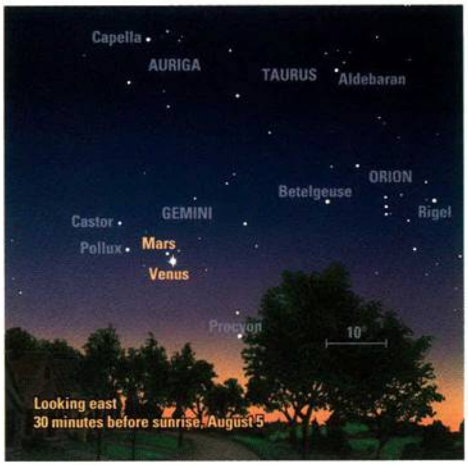
Pale blue **Neptune** reached opposition last month and is now a dim evening planet at magnitude 7.8. You can find it near the Sagittarius/Capricornus border.

After passing opposition in May, **Pluto** crosses briefly into Scorpius this month. The planet is in the final part of its retrograde loop and still can be found by using the 14th-magnitude star Zeta (ζ) Ophiuchi. Next February, the planet once again becomes the ninth planet from the sun, when it crosses the orbit of Neptune. Since 1979, Pluto has been closer to the sun than Neptune.

Morning Sky Jam

August is the month for early morning solar system action. As Venus gradually relinquishes its dominance of dawn's eastern horizon, Mars climbs past it. The Red Planet is followed quickly by Mercury, which is on the way to its best morning display of the year. The biggest hurdle to overcome is personal — dawn comes in the wee hours for northern observers.

Brilliant Venus, at magnitude –3.9, points the way to the feeble coppery glow of Mars in the opening week of August. Mars lies a mere 0.9° north of Venus on August 5. You may need binoculars to spot its 1.6-magnitude glow against the brightening twilight. Mars climbs up away from Venus by a moon's width a day.



Looking east
30 minutes before sunrise, August 5

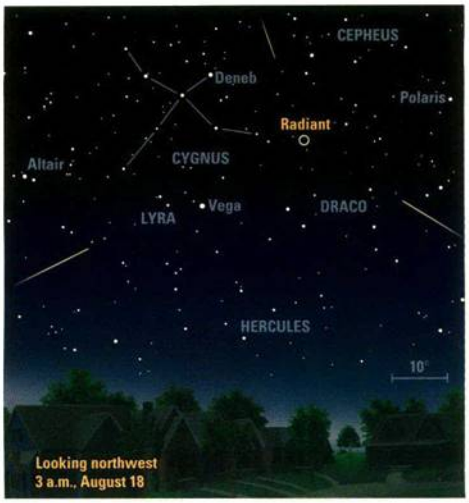
On August 19 and 20 the waning crescent moon drops down to add beauty to the scene. Seek out Venus in a scope on the 19th. Watch it slide along the southern edge of the sparkling Beehive Cluster (M44). Try to see some of this beautiful cluster's stars against the twilight.

Fleet-footed Mercury vaults into the morning sky at the end of the month. The last three days of September find the magnitude 0.7 planet to the right of blazing Venus. This will be a nice opportunity for some scenic photography.

A final bonus arrives on the morning of September 1. Mars slides just south of the core of the Beehive Cluster. The contrast of the reddish glow of Mars with the stars of M44 should be a beautiful sight. Use a pair of binoculars to gain a nice, wide field of view.

An Old Favorite: Kappa Cygnid Meteors

August meteor showers tend to be overshadowed by the bright streaks of the Perseids. This month, as the moon frowns on the Perseids, barely a Cheshire crescent smiles upon the Kappa (κ) Cygnids — a favorite among long-time meteor watchers.



Looking northwest
3 a.m., August 18

The Kappa Cygnids are well known for their bright, graceful, splashy streaks and occasional fireballs. The only drawback to this shower is its lean rate. You may expect only two to six meteors per hour — just right for a very relaxed observing approach.

The shower is active throughout the month, coming to a gradual maximum on August 18. With new moon occurring on Friday, August 21, the weekend will be a good time for observing.

Keep watch for slow meteors — about ⅓ the speed of the Perseids — radiating away from the left arm of the Northern Cross. Some slide down the Milky Way, while others shoot directly away from it. Another weak shower will be returning fire, the Northern Iota (ι) Aquarids. This shower sends faint slow meteors from the south, opposite the Kappa Cygnids.

Three planets congregate in the morning sky during August, and the crescent moon swings by each of them. **Mars** and Venus lie within 2° of each other during the first week of the month. They then move slowly apart as the month progresses. Both planets can be seen with the Beehive Cluster (M44), in Cancer the Crab, at mid-month.

While Venus makes its way toward the sun's glare, Mercury rises from the brightness to meet her. Mercury is just coming out of its August 13 inferior conjunction and brightens rapidly to magnitude –0.2 by month's end. September will find both planets gathered around the bright star Regulus in Leo the Lion. Regulus marks the period in the backward question mark of Leo's head.

An annular eclipse of the sun occurs on August 22 for observers in Indonesia and Polynesia. A partial eclipse will be experienced by a significant portion of China, Asia, Australia, and New Zealand. No part of the eclipse is visible from the United States or Europe. This event is a curiousity because the eclipse track crosses the International Date Line. It begins to the east of the dateline where it is August 22. The eclipse ends to the west of the date line, where the day is August 21. This apparent paradox is caused by the fact that the eclipse occurs at midnight as timed in Greenwich, England, where the universal or international time system is based.

Martin Ratcliffe is Director of Theaters at the Exploration Place in Wichita, Kansas. Alister Ling is a meteorologist working for Environment Canada in Alberta.

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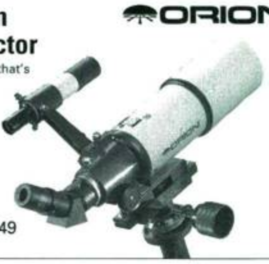

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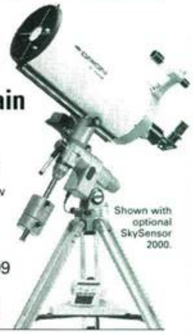

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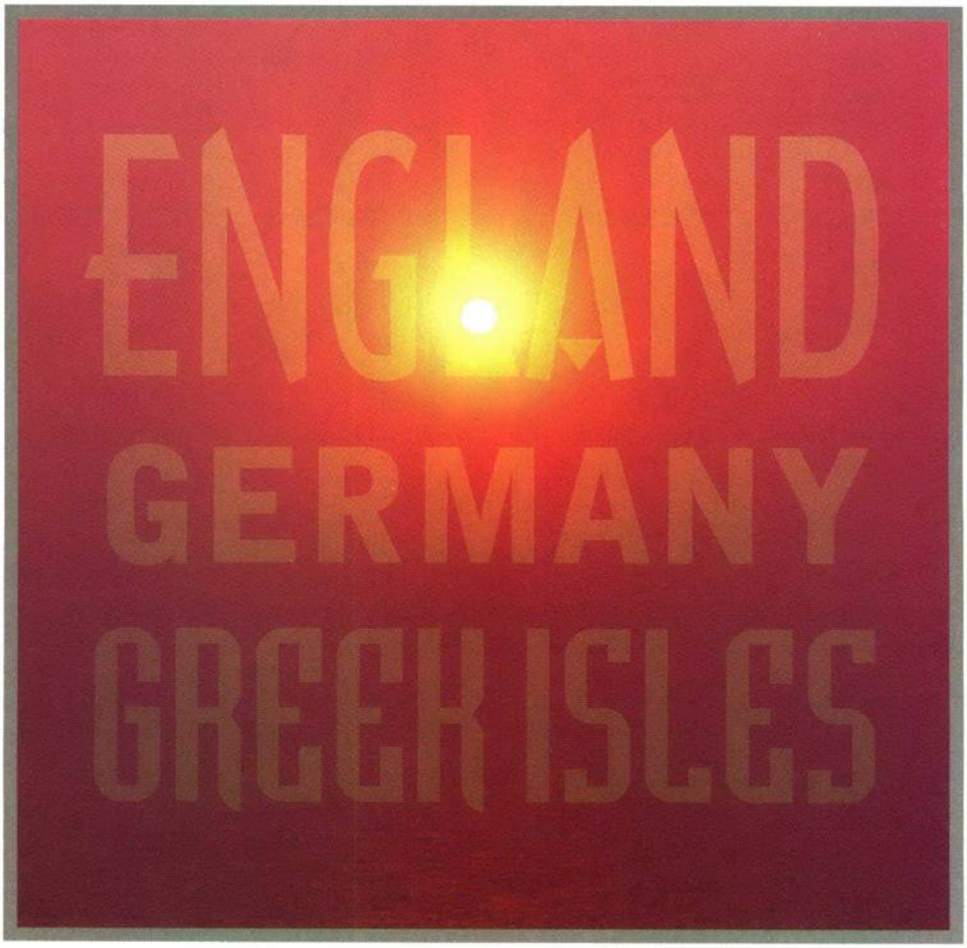
1999 solar eclipse tours



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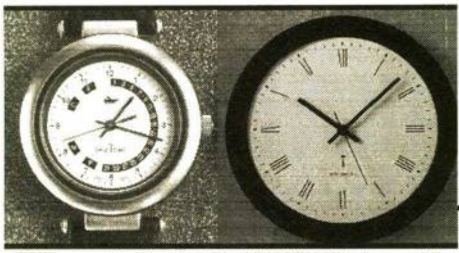

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Observing Contest

Starlight Seductions

Three observers share experiences that transformed their lives.

Compiled by Andrea Gianopoulos

With more than 200 submissions from seven countries, our "Greatest Observing Experience" essay contest brought in a diverse range of topics, scenes, and emotions. Many of you wrote about comets — Hyakutake, Hale-Bopp, Austin, West, and Halley were all represented. Other popular themes included aurorae and eclipses. Nearly 95 percent of the essays concentrated on naked-eye observations — even those from hard-core 20-inch Dobsonian telescope owners. So what was the common thread? Astronomers tend to be an inquisitive lot with a strong affection for the beauty of the night sky — many of you expressed yourselves quite poetically.

The three winners we present here each receive a publication fee of $500. Nik Szymanek of West Horndon in Essex, Great Britain, writes of his time observing at a world-class facility in "La Palma." Kenneth Rubin of Wantagh, New York, recalls his "First View" in a delightful story about the sacrifices made to purchase a 3-inch Newtonian reflector. Our final story comes from Sonya Thomas-Haley of Rapid City, South Dakota. In "A Night in the Badlands," Sonya tells us of her first public star party. Her experience relates the concerns and pleasures of sharing the night sky. We hope you enjoy these stories as much as we enjoyed reading your entries.

In this composite image, the Milky Way rises over the William Herschel Telescope at sunset. Nik Symanek and Ian King

Suddenly I knew what it felt like to be really alone.

I opened the dome door and stepped outside onto the crisp, dry snow. A cold wind blew from the west — clear, fresh air like that never experienced from my home in England. An almost perfect silence greeted me, broken only by the muted, distant rushing of the circulating fans of the William Herschel Telescope just down the hill. Glancing upward, I saw the sinister silhouette of the new Dutch Open Telescope — looking for all the world like a Fighting Machine from H. G. Wells's *War of the Worlds*. But rather than stalking an alien landscape, this structure stood aloof, ignoring the night, waiting patiently for dawn and the rising of our daytime star.

My companions had left earlier, the long nights had taken their toll. After traveling to La Palma in the Canary Islands, one of the world's best astronomical sites, I knew that every moment viewing this pristine sky had to be savored. I felt exhausted with the strain of nursing our telescopes, CCDs, and computers, and the reduced atmospheric pressure occasionally muddled my senses. But now, in the early hours of a perfect night, I decided to walk away from the dome and really experience the sky.

A primal instinct warned me that I was at the summit of a volcanic island, with an 8,000-foot precipice in all directions. Starlight illuminated the scene and the powdery snow glistened underfoot as I walked down the slope to a vantage point that allowed me to look southward to the gently active volcanic craters 18 miles away. The stars of the far south shone above the distant landscape, stars that could never be visible from home. The magnificent globular cluster Omega Centauri hung serenely in a velvet-black sky and the bright jewel Canopus shone unwaveringly. Thousands of feet below in the volcanic crater, low-level clouds, illuminated from beneath, gave off an eerie, luminous glow.

RONOM
is looking

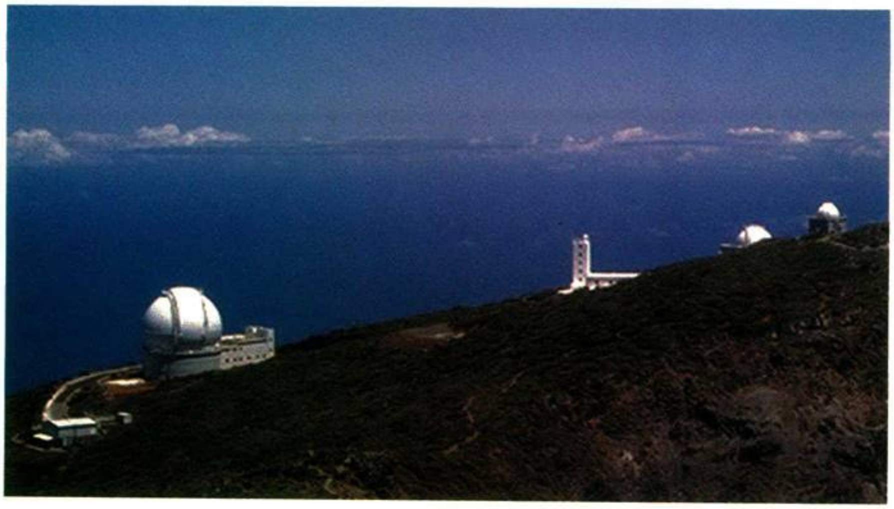
Nik Symanek (left) traveled with his friend Ian King to the island of La Palma in the Canary Islands to observe with the Jacobus Kapteyn Telescope. Nik Symanek and Ian King

I savored this scene for many minutes before walking back up the hill. The dome of the William Herschel telescope was a gray orb, punctuated only by the dark, open slit. I wondered where in the furthest reaches of our universe this great glass eye was peering. Suddenly, as if to answer my thoughts, the huge dome rumbled around before it settled down to stare at some new vista and return the site to stillness.

The sky overhead blazed with unimaginable beauty. The winter Milky Way, all but invisible through the ghastly, ghostly-gray skies of England, glittered serenely through Orion before meandering down into strange, unfamiliar constellations not seen in Britain. Sirius, normally flashing madly in the murky air, hung like a diamond on black velvet. The pristine skies of La Palma are famous, not only for an incredible transparency, but for a steadiness possibly unparalleled in the Northern Hemisphere. Every few moments a bright meteor slashed through the night and occasionally one would end its life, apparently extinguished in the ocean far below. I could only imagine how a bright shower like the Perseids would look from this magnificent site.

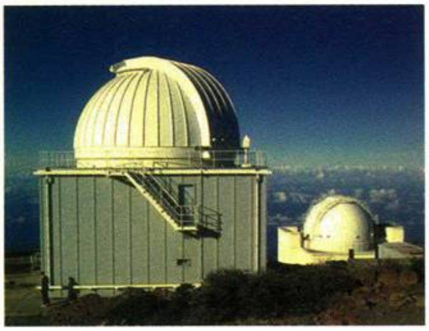
I recalled the experiences we had shared during the last few days. Thanks to the incredible generosity of our friend John Mills (a technician employed by the Isaac Newton Group of telescopes on La Palma) and his colleagues, who let us use the Swedish 25-inch telescope and dome, our telescopes and CCDs had been installed in the dome, and we were left to practice amateur astronomy from a site with few equals. As soon as the sky darkened, we began a CCD integration and gasped aloud as the image unfurled on the computer screen — an image far superior to those obtained at home. I recall that every so often I would have to leave the high-tech world of telescopes, autoguiders, and computers to step outside and marvel at the majestic spectacle overhead.

Now, in the silent stillness, I thought of the beautiful sunset I had witnessed from above the clouds hours earlier. A



The Isaac Newton Group of telescopes — (l. to r.) the William Herschel Telescope, Swedish Solar Tower, Isaac Newton Telescope, and the Jacobus Kapteyn Telescope. Nik Symanek and Ian King wedge of shadow had been projected by the island onto the clouds below, as the steadily darkening sky possessed a hue that sang with authority of the wonders to come. The zodiacal light, so elusive from our northern clime, arched gracefully to the zenith, a majestic cone of comet dust. With the night came naked-eye views of familiar deep-sky friends like the Andromeda Galaxy and M33. My humble binoculars provided views that turned these objects into classics, almost matching the photographic images seen so often in astronomical publications. It's at this time that our work would begin — image after image gathered and safely stored on the hard drive for later processing. But our time here was now at an end.

All too soon the night was over and the first rosy glow of dawn competed with the morning zodiacal light. I walked down to the Jacobus Kapteyn Telescope and waited for the sunrise. Across the ocean, 70 miles away, the island of Tenerife rose out of the haze. Even at that distance, I could plainly see the snow on the upper peak of the island. Suddenly, a glowing yellow star burst over one of the distant island's rocky slopes. I searched in vain for the elusive green flash, as the clouds below sprang to life with the growing sunlight. Behind me, the familiar wedge-shaped shadow of La Palma sprawled across the sea of vapor. As I watched in silence, I saw two professional astronomers who had been observing. They also witnessed the magnificent sunrise from their dome's catwalk. They waved a friendly greeting before disappearing back into the dome. One final spectacle completed this night of nights; as I stood with my back to the warming rays of the sun, on the clouds below appeared a fantastic glory, an almost complete circle of rainbow light with my own shadow at the center.



The Jacobus Kapteyn (1m) and Isaac Newton (2.5m) telescopes. Nik Symanek and Ian King

"Thank you" was my final thought to the soul of the sky.

First View *by Kenneth Rubin*

It was the summer of 1963, a time affectionately called the "Camelot Years." Neil Armstrong's "one small step for man" still loomed six years in the future, the first Celestron 8-inch Schmidt-Cassegrain telescope wasn't built yet, and there weren't any Dobsonians or apochromatic refractors. Nagler and Panoptic eyepieces didn't exist, and no one even imagined marvels like CCDs, digital setting circles, or computerized telescopes.

It was during those early years of amateur astronomy that my brother and I decided we had to have a telescope. I had devoured every book I could find about astronomy since the time I was in the second grade, and now I felt an overpowering urge to experience the universe first hand.

My brother was 14, and I was 15. Following the death of our father seven years earlier, we had moved into an apartment building in the Bronx, New York. Money was very tight, so we knew better than to ask our mother for a telescope. The only way we could get one would be by making our own sacrifices.

Our goal was to save what we considered to be the huge sum of $29.95 to buy an Edmund 3-inch f/10 Newtonian reflector. Back then, that amount of money represented half a week's gross salary for our mom.

We knew that once school started, we would each receive forty cents a day for lunch. Our plan was to save four dollars a week by skipping lunch every day. We kept our minds off our grumbling stomachs by talking about the wonders of the night sky that we soon would be able to see. After nearly two months, we finally saved enough money to order our telescope. As an added bonus, we earned the privilege of eating lunch again.

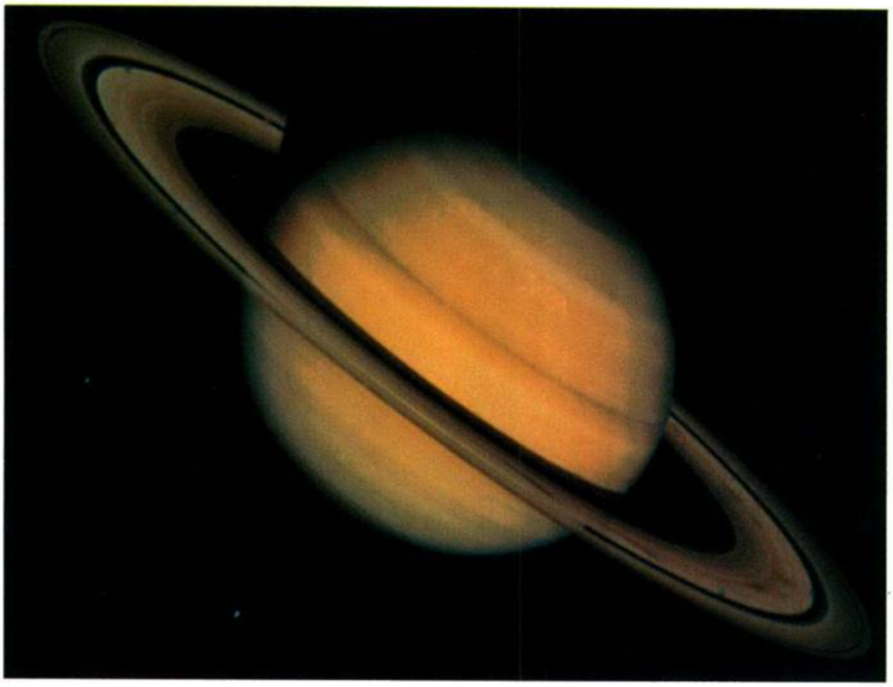
Ken Rubin's brother Steve takes his first look at the moon through their new 3-inch Edmond Reflector circa 1963. Kenneth Rubin

When the scope arrived late that October, we were so thrilled that we beamed from ear to ear. Our mom, on the other hand, was flabbergasted.

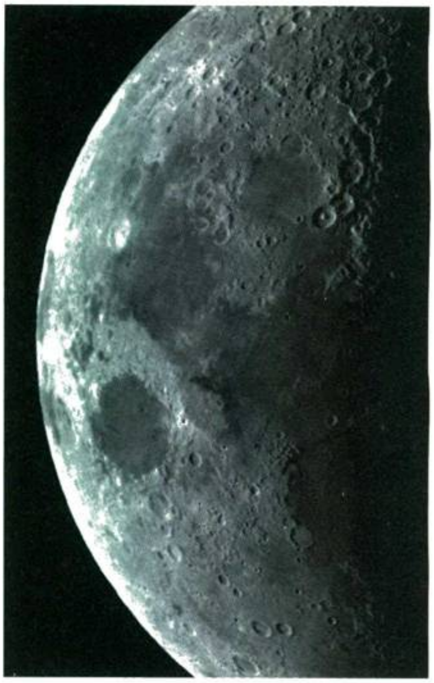
We opened the box to discover a gleaming white cardboard optical tube and all the parts and accessories that came with it. We carefully assembled our new treasure, checked the collimation of the primary and secondary mirrors, and finished by collimating our 3x non-achromatic finderscope. To us, our new telescope, on its simple equatorial fork mount and tripod, was truly a thing of beauty.

Luckily, the sky was clear that day. There was a gibbous moon just beckoning to us, and the few hours we had to wait for darkness seemed like an eternity.

Finally, the time came to try out our new scope. I carried it into the elevator of the apartment building, pushed the button that brought us to the sixth floor, then climbed the extra flight of stairs that took us to the roof. It was so quiet up there. It seemed like nothing existed other than our telescope and the sky above us.



Ken Rubin's "discovery" of Saturn during that first observing session contributed to his 35-year love of astronomy. JPL



The first view of maria, craters, and mountain ranges compelled these brothers to seek out further wonders. David Hanon

We pointed the scope toward the moon, and since I was a year older, I claimed the honor of placing our 12.5mm eyepiece into the plastic drawtube. As I slowly twisted the eyepiece into focus, I couldn't believe what I saw. There were maria, craters, and mountain ranges, all seen with my own two eyes. To me, the moon was stunning. It looked better than the pictures I had seen in books, and my eye remained fixated on the incredible view.

Suddenly, my brother's voice broke my concentration. "Hey, don't hog the telescope. I want a look, too!" In the excitement, I had totally forgotten about him. I reluctantly stepped back so he could get to the eyepiece. He too was blown away by the experience.

After a few minutes, I remembered that our scope also came with a Barlow lens, which would increase the magnification. The image was brought back into focus and wasn't nearly as sharp as it had been before, but I really didn't care. The moon seemed so close, and I felt like I was in lunar orbit.

My brother and I took turns observing the eerie lunar landscape. I remember being totally awe struck by the wealth of crater detail.

We had been observing for quite a while, and as it grew even darker I saw a fairly bright star close to the moon. We decided we'd take a look, so I removed the Barlow and placed the 60x eyepiece back into the drawtube. When I brought the "star" into focus, I found myself looking at a tiny disk with what appeared to be a ring around it. The reality suddenly hit me and I yelled, "Oh God, I just found Saturn!" I couldn't believe that I was actually seeing Saturn's rings with my own telescope.

After a few seconds, my brother practically threw me out of the way so he could have a look. When we increased the magnification, any remaining doubt concerning our discovery was gone. We spent the next half hour spellbound as we shared views of the beautiful ringed planet.

Nearly 35 years have passed since that night, and our 3-inch reflector is long gone. Today I observe with an Ultima 8-inch Schmidt-Cassegrain telescope and an 80mm fluorite refractor; and yes, I even own the digital setting circles and other gadgets that I never imagined.

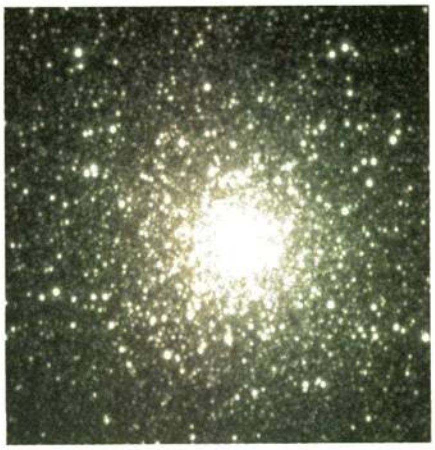
Although my scopes have gotten better through the years, and I've had numerous, wonderful observing experiences, my best experience will always be that first view of the moon and Saturn through that little telescope, which was purchased long ago with lunch money.

A Night in the Badlands *by Sonya Thomas-Haley*

In the summer of 1995 my husband volunteered to help with an astronomy program at Badlands National Park in South Dakota. The park rangers had a couple of 8-inch telescopes at their disposal and a place to set them up right next to the campground. What they lacked was extensive astronomical knowledge. On the spur of the moment, my husband volunteered to bring our Meade 10-inch LX200 Schmidt-Cassegrain telescope out there a couple nights a week. My first reaction was: "You're going to subject our $3,000 telescope to tourists and kids?" I promptly volunteered to come along as the telescope's bodyguard. While he set it up, operated it, and answered questions, I planned to keep my eyes glued on this expensive piece of hardware so that no pudgy little finger strayed anywhere near a multi-coated lens.

Little did I realize that in the course of that night, my role would change, as would my appreciation of what astronomy is really all about.

Silhouetted against a violet twilight sky, one of the park rangers came over and asked if we wanted to give an introductory talk when they brought the people over after the amphitheater show. I ducked into the deepening shadows and pretended to be occupied with some star charts. Me? Give a spur-of-the-moment, off-the-cuff talk on astronomy to an audience of strangers? No way. My husband agreed to say a few words. As the audience assembled and sat down on the gritty prairie soil, I kept out of the way, leaning against our Bronco, sizing up the boisterous teenagers and hyperactive kids, looking for troublemakers.



LEFT: The globular cluster M13 in the constellation Hercules is usually a favorite at public star parties. Its compact form and millions of stars always draw lots of oohs and aahs. Kim Zussmen

My husband punched numbers into the keypad and an impressed hush fell over the crowd as the telescope obediently slewed to the desired location in the sky. Jupiter. The people lined up, about 30 of them, to take a look. I stationed myself right next to the scope and showed each person where the focusing knob was.

Then somebody asked a question. "Are those stars right next to it?"

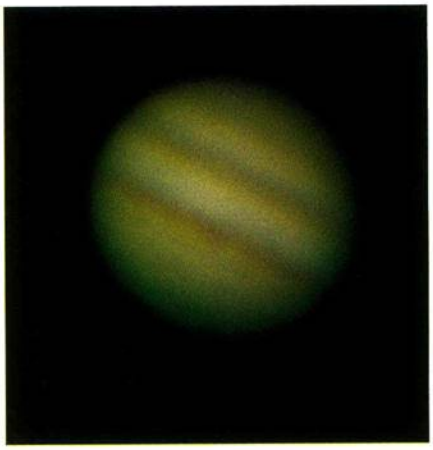
I expected my husband to answer all questions. But I saw he was busy with someone else, so I mumbled, "Those are moons."

The next woman asked, "How many moons are there?"

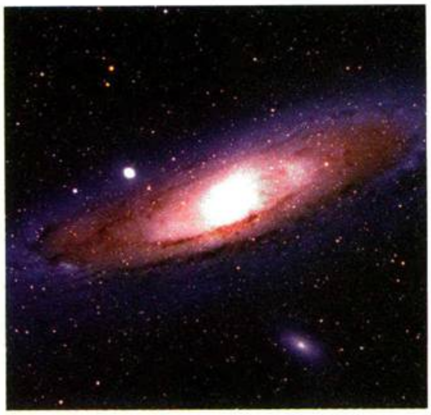
I said, "You can see four." I added, "At last count, astronomers have found 16 moons around Jupiter." She blinked at me. She looked impressed. Whether at the number of moons or at the fact I knew the number of moons, I'm not sure. But people further back in line began to notice me and direct questions to me.

Perhaps it was the darkness — the black velvet night with little else than starshine to illuminate faces — that lent me confidence. That kind of darkness lets you feel somehow anonymous, as though you're wearing a Halloween mask, allowing you to be somebody else. Somebody other than a shy, self-conscious young woman. I answered more questions, I spoke a little louder, and pretty soon I was volunteering information. They treated me like some kind of expert, which I wasn't, but I did my best.

By now the park rangers had dragged my husband over to help them with their 8-inch scopes, which left me alone manning our scope. After Jupiter, people stood around expectantly. I said, "Okay, how about we look at the remnants of a stellar explosion?" That got their attention. I slewed the scope up to the Ring Nebula and talked about planetary nebulae.



RIGHT: With the help of Sonya and her 10-inch LX200 scope, roughly 30 people glimpsed Jupiter and its moons through the eyepiece for the first time. Philippe Durville



BELOW: A seven-year-old boy contemplated the size of the universe as he viewed the Andromeda Galaxy (M31) some 2.2 million light-years away. Jerry Lodriguss

Next stop, Albireo. When I mentioned that most stars are part of double or triple systems, that sparked a debate between a couple of college students over the metaphysical significance of our solitary sun's relative uniqueness. A pretty heated debate. I just smiled and carried on. I was a tour guide now, and I was having fun.

I slewed all over the sky, the drive motor humming and whirring. M13 drew many gasps of surprise. I announced the cluster contained more than a million stars. An old woman, her head bent over the eyepiece, echoed in an awed whisper, "a million."

The hours went by and people drifted off to their tents, RVs, and motels. But half a dozen or so were too mesmerized to leave. One pair in particular stands out in my mind: a boy of about seven and his attentive mother. I showed him the Andromeda Galaxy. He was a bright kid. I asked him if he understood the speed of light. He said yeah, he knew all about that stuff, how the light takes years and years to reach us. As he studied Andromeda, I said, "Just think, you're looking two million years back in time." He glanced at me, his eyes all big and wide. "Wow," whispered his mother.

The sky program at Badlands National Park has since been discontinued, largely due to lack of funds. Once in a while, we drive back out there and set up our scope by ourselves. The only major light pollution comes from an occasional car driving past — its headlights illuminating the rock formations like the floodlights on a movie set. Each time, I can't help but think that this is a show that deserves an audience and a stage that needs performers.

The greatest observing experience I ever had was observing other people looking through our scope. With all due respect to solitary observers, you haven't experienced the real fun of astronomy until you've shared it with others.

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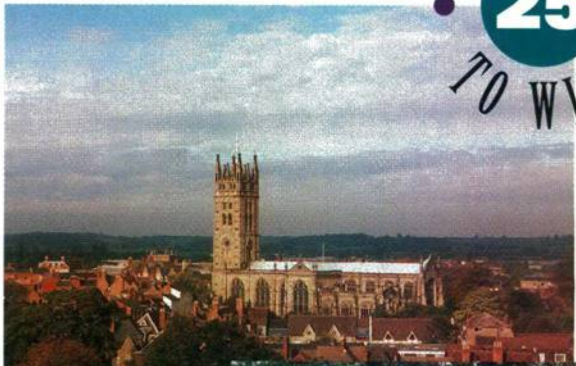
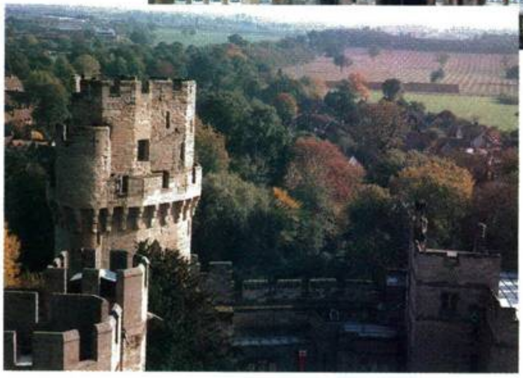
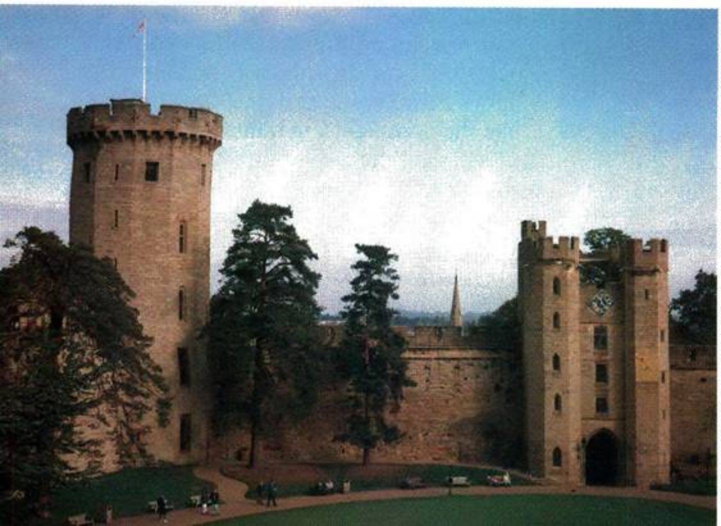
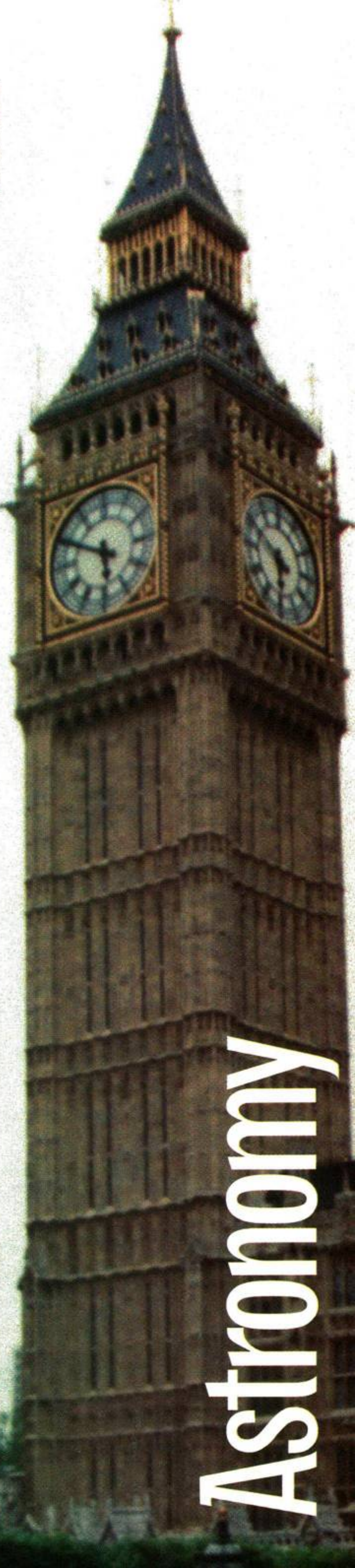






Big Ben and Guard photos by Louie Borth. English countryside photos by Bill and Cindy Barder.



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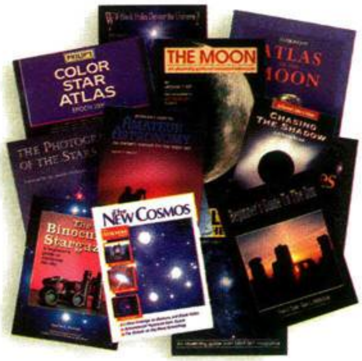

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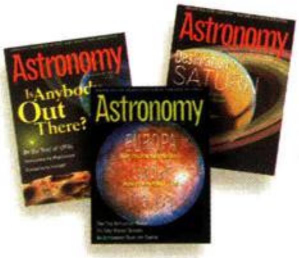

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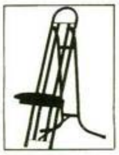

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Mention Ad A-7

Telescope-Making REVOLUTION

When Astronomy *was young, revolution was in the air. Large aperture telescopes soon changed the way amateur astronomers practiced their hobby.*

by Richard Berry

When Stephen Walther founded *Astronomy* magazine 25 years ago, the science and hobby of astronomy was different than it is today. Quasars were newly discovered, moon walks were a recent memory, and the Viking landings on Mars were yet to come. Amateur astronomy was primarily a hobby of small telescopes: If you owned a 2.4-inch refractor, you were among the fortunate few who owned a telescope at all.

In the 25 years since the magazine's first issue, astronomy has undergone vast changes, but in the area of telescope making, no change even comes close to the breadth and depth of what has been called "the Dobsonian revolution." Created by John Dobson in the early '70s, the Dobsonian telescope had a unique design that dramatically increased telescope aperture while decreasing the cost of owning a telescope. It changed the focus of amateur astronomy away from backyard moon and planet observing to dark-site, deep-sky observing.

Telescope: *Astronomy* Background photo: Tim Barnwell

When he founded *Astronomy*, Steve Walther had done his homework. Walther could rattle off statistics about what percentages of amateur astronomers owned this and that, and he knew how many dollars they spent on their hobby. His 1976 reader surveys showed that the majority of *Astronomy* readers did not own a telescope, and those who did probably owned a 2.4-inch refractor.

No change even comes close to

John Dobson revolutionized amateur astronomy. Meet him on June 25 at *Astronomy's* 25th Anniversary Star Party in Albuquerque, New Mexico. Richard Berry

If you went to a star party you might see a scattering of 6-inch Newtonian reflectors, but the big telescopes were tucked away. Everyone had heard about the white-haired gentleman who lived near the edge of town and set up a 10-inch telescope in his back yard. Chances are he was an amateur telescope maker. He had ground and polished the mirror, crafted the shafts and bearings of the mounting on the lathe in his basement, and built a clock drive from war-surplus aircraft parts. He was a member of the elite: He observed planets for ALPO (Association of Lunar and Planetary Observers) and variable stars for the AAVSO (American Association of Variable Star Observers). He was an amateur astronomer and proud of it.

But Walther's credo was populist: "*Astronomy* is a magazine for astronomy enthusiasts," he declared. "We write for novices, not for amateur astronomers. We're a magazine for the average Joe." With the hindsight of 25 years, we know that Joe wasn't happy with his novice status or his 2.4-inch refractor. Since the early 1960s, Joe had aspired to bigger and better things.

In the years following World War II, entrepreneurially minded amateur astronomers had established companies that offered war surplus optics and supplies for telescope making. Telescope making was big because finished telescopes were expensive. A 3-inch refractor equipped with slow-motion controls cost $265, real money in 1949, but a kit to make a 6-inch mirror cost only $4.

In the decades that followed, the manufacture of ready-made telescopes grew, but the price remained too high for the average wage-earner. In 1960, for the price of an 8-inch Newtonian, you could purchase a good used car. Furthermore, despite its growth, the telescope industry was remarkably static in the ten-year period between 1955 and 1965. Look through old magazines and you'll find telescope advertisements that remained virtually unchanged for a decade — the same copy, the same pictures, the same products.

But as the 1960s drew to a close, things began to change. The moon race drew attention to space and to astronomy. Inexpensive imported 2.4-inch refractors and basic telescopes like the Criterion RV-6 reflector were selling well, and Tom Johnson was experimenting with a novel high-tech telescope design called the Schmidt-Cassegrain.

Meanwhile, on a street corner in San Francisco, an ex-monk named John Dobson was showing off the universe through homemade telescopes. Dobson built telescopes from junk he scrounged — cardboard hose-reel tubes and mirrors ground from war surplus battleship portholes. Because he could not afford a machined metal mounting, Dobson adopted a simple trunnion mounting of the type long used for cannons. His telescopes were uniquely simple, easy to use, inexpensive, and large. At a time when 2.4-inch refractors were the norm, Dobson was showing the moon to sidewalk passers-by with a 12-inch reflector.

An astute friend realized that Dobson could earn much-needed money by teaching others how to make telescopes and arranged for him to begin teaching telescope making and astronomy at the Jewish Community Center. The following year, two of Dobson's friends insisted that he join them in forming the San Francisco Sidewalk Astronomers, an astronomy club that met at the corner of Jackson and Broderick Streets, on the sidewalk, with telescopes for public stargazing. Dobson's 12-inch telescope was joined by Cyclops, a 16-incher, and The Little One, an 18-incher.

the breadth and

A compact design with high-end optics contributed to the popularity of these Questar (above) and Celestron (r.) telescopes. Questar and Celestron

Amateur astronomers found it difficult to accept Dobson's big telescopes and novel ideas because he challenged accepted notions. His telescopes were made of cardboard and wood and lacked precision machined parts. More than a decade of sidewalk astronomy passed as John Dobson, building some of the largest amateur telescopes in the world, was almost totally ignored.

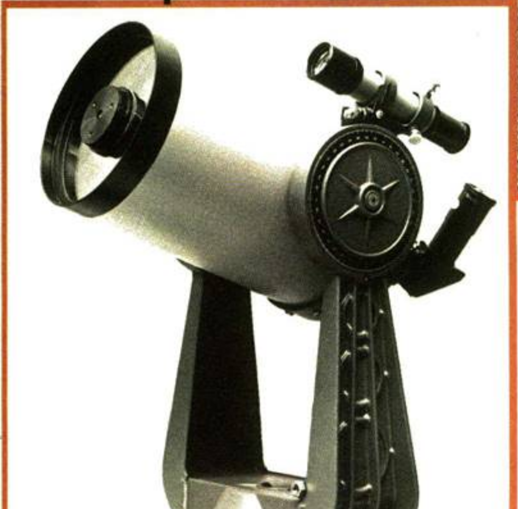
During that ten years, other things happened. The entrepreneurial Tom Johnson introduced the Celestron Schmidt-Cassegrain, a compact and highly portable 8-inch telescope, for $899. The C-8 was a big step forward in aperture, and the average Joe Amateur began to suffer from aperture envy.

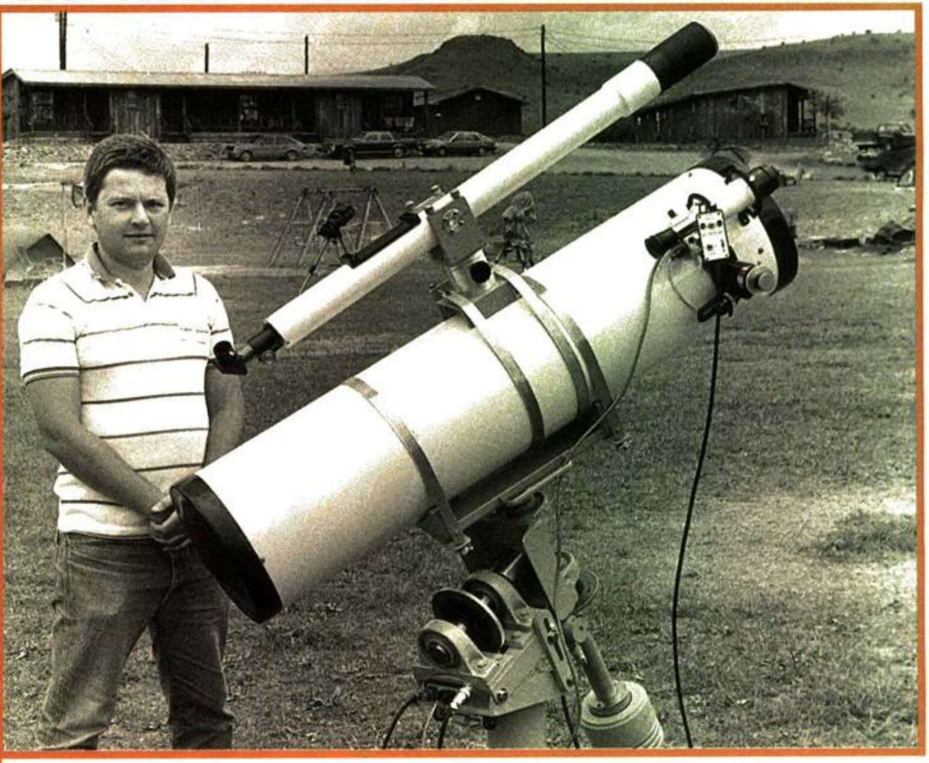
The first issue of *Astronomy* magazine appeared in August 1973. Three years later, in June 1976, Steve Walther had convulsions at a party, was taken to the hospital, and was shortly thereafter diagnosed with a rapidly growing brain tumor. He died 13 months later, leaving the fledgling *Astronomy* struggling financially and me the de facto editor. Steve Walther's brother David, an attorney in Milwaukee, now owned the magazine and the company that published it, AstroMedia Corp.

Another five years passed, and Johnson's Schmidt-Cassegrain telescopes sold well. *Astronomy* grew, too: It had become the magazine of choice for astronomy enthusiasts. But some people said it wasn't technical enough — an attitude that's a bit hard to imagine in today's world.

To answer that criticism, AstroMedia launched *Telescope Making*, a low-budget magazine technical enough to satisfy hard-core amateur astronomers, thereby gaining credibility for AstroMedia. The first issue of *Telescope Making* appeared in the autumn of 1978.

depth of what has been called "the Dobsonian revolution."





Before the Dobsonian, Mark Komsa's 10" reflector and heavy-duty mount was the norm for large aperture telescopes. Richard Berry

In the late 1970s, only two annual conventions catered to amateur telescope makers: the Stellafane convention held every July or August in Springfield, Vermont, and the Riverside Telescope Makers Conference held each May in Big Bear, California. At Stellafane in 1978 I saw my first Dobsonian — a 16-inch telescope built by Dennis di Cicco based on Dobson's ideas. I was impressed by how smoothly the altitude-azimuth mounting moved, so that summer I remounted my own 12-inch f/7 Newtonian on a simple alt-azimuth mount. The experiment was a success: My 12-inch telescope had never before been so easy to point and so much fun to use.

The following spring, I attended the 1979 Riverside Telescope Makers Conference hoping to meet Dobson, so you can imagine my disappointment when I discovered that he was not there. But Doug Berger, Earle Watts, and Bob Kestner, all members of the Sidewalk Astronomers, were there, so I interviewed them and spent an evening observing with Doug's telescope. When I felt how smoothly the mount moved and saw how good the images from his 1-inch-thick mirror were, I said so. They could hardly believe their ears.

It is hard to imagine how difficult the late 1970s were for Dobson's followers. People would walk up and say straight to their faces that these funny-looking telescopes were no good and they couldn't work. Many of the people who said these things had never actually looked through a Dobsonian telescope.

Meanwhile, other events were leading toward a Dobsonian "revolution." By 1979, the cost of ready-made telescope mirrors had fallen. Many telescope makers purchased these mirrors rather than going through the time honored (and time-consuming) process of making their own, yet there was no commercial source for large mirrors suited to Dobsonians. Then something strange happened.

Jim Jacobson, the owner of Coulter Optical (a company that made telescope mirrors) had invested heavily to expand his optical production facility to fill a contract from a company that sold ready-made telescopes. When the other company hired away Coulter's optician and canceled the contract, Jacobson was stuck with a big debt and far more production capacity than he needed. Jacobson decided to put his overcapacity to work making mirrors for large Dobsonians. When he announced he would be selling 17.5-inch f/4.5 mirrors for $595, Jacobson was deluged with orders.

Jacobson realized that without instructions his big mirrors would be useless to many buyers, so he approached AstroMedia for 2,500 copies of a reprint booklet that would include *Telescope Making*'s articles about building Dobsonians. By July 1980, a skinny little booklet with red covers called "How to Build a Dobsonian Telescope" was rolling off the presses. Jacobson mailed a copy to everyone who requested information about Coulter mirrors, and he packed the booklet with every mirror he sold. Available optics made big low-cost telescopes a reality.

During the early 1980s, amateur astronomy expanded prodigiously. Although factors such as the success of the Voyager missions to Jupiter and Saturn contributed, Dobsonians undoubtedly played a key role in the expansion of astronomy as a hobby. By lowering the cost of acquiring a telescope, Dobsonians made amateur astronomy attractive to more people. The hobby grew to four times the size it had been a decade earlier. New companies were founded, astronomy clubs appeared, and star parties multiplied. Amateur astronomy appeared to be a growth industry.

Nourishing that interest was *Deep Sky Monthly* (renamed *Deep Sky* when AstroMedia acquired it), which provided observers with extensive lists of objects to observe and served to rally their enthusiasm. The magazine was started by *Astronomy*'s managing editor David Eicher when he was 15 years old. Although it carried a column for users of small telescopes, *Deep Sky* catered primarily to amateurs with large Dobsonians.

Paradoxically, the low-tech Dobsonian seems to mesh extremely well with high-tech accessories like light-pollution filters, high-end eyepieces, and digital setting circles. As big Dobsonians

With optics available,

Introduced in the early 1980s, Astro-Physics refractors are designed by an avid amateur astronomer who was dissatisfied with the telescopes of the 1970s. Astro-Physics

A Telescope in Every Closet?

In the good old days, amateur astronomers had to make their own telescopes. Spurred on by the articles of Albert G. Ingalls and others in *Scientific American*, amateur scientists in the 1920s and 30s had no other choice. To see stars and planets, they put grit to glass and ground their own mirrors, fashioned tubes, and outfitted accessories to make highly individual, inelegant, functional creations. The second explosive wave of telescope making came with the Dobsonian revolution in the 1970s and 80s, fired by the simple mounting design of John Dobson. Now the drive wasn't simply getting a telescope, but getting a large one.

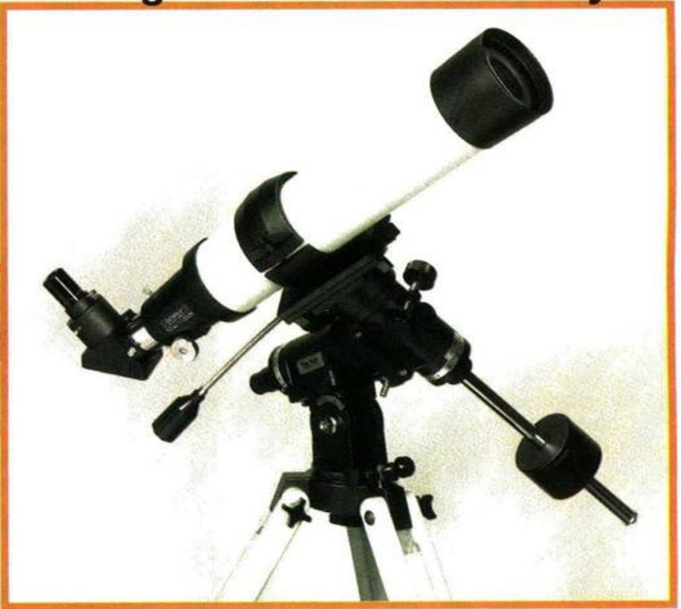
During the early 1970s, the popularity of Criterion's Dynascope RV-6 brought 6 inches of light gathering power into an affordable package. But the real turning point in commercial telescope production came with Celestron's introduction of an 8-inch Schmidt-Cassegrain telescope (SCT). This instrument packed enough light-gathering power to not only see planets and small objects well, but to find deep-sky objects that had previously been considered invisible to amateurs. "The Veil Nebula is beyond the visual limits of backyard telescopes" was an actual phrase in an observing article of the day; the C-8 proved it folly. The instrument's stubby, compact tube and futuristic (by early 70s standards) design gave it instant allure.

The ease of use and completeness of accessories offered by the C-8 brought astrophotography into the mainstream of amateur activities. Celestron's success led Meade Instruments to bring their own expansive line of SCTs into the market. It now stands as the largest and most active company in the entire field. Meanwhile, refractors — often pushed into the background as cheap, department-store items without redemption — began a quiet renaissance. By the early 1980s, Astro-Physics and Tele Vue began revolutionizing commercial refractors by constructing them with high-quality apochromatic lenses. Suddenly amateurs discovered the satisfaction of having sharp, high-definition views across flat fields.

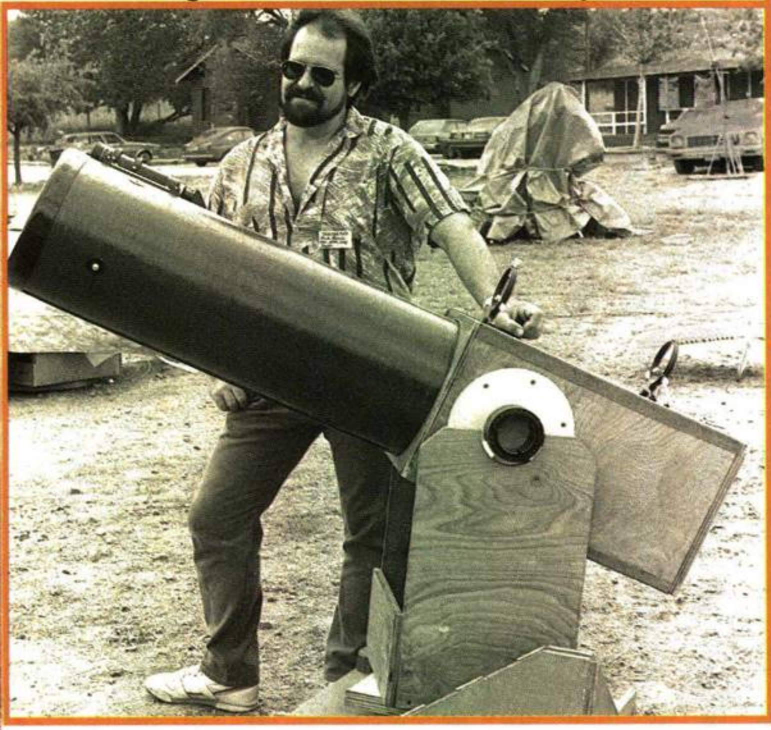
Before the revolutionaries knew it, commercial ventures had picked up on their designs for Dobsonians. By the early 90s, large Dobsonians suffered the same fate as telescopes in general — no longer did one have to build a telescope. It was now possible to plunk down a credit card and buy a large Dobsonian ready-to-use. Coulter Optical Co. was first in pioneering the concept of a simple, commercial Dob. Then specialists came into the fore with different design twists and luxuries to compare, some of the most active being JMI, Obsession, Portaball, and Starsplitter.

Today the profusion of commercial scopes is dizzying. Few scientific fields offer such diversity and quality in instruments that can be bought without a second mortgage and offer us the whole universe from our backyards. Now, with a quality telescope, we can explore thousands of objects in the Milky Way and thousands of galaxies and even quasars beyond. "Unk" Ingalls, familiar with grinding 3-inch lenses as outlined in his columns in *Scientific American*, would never have believed it. — *David J. Eicher* attracted more observers to the deep sky, the need for light-pollution filters grew. Among the first to offer an effective filter was physicist-turned-entrepreneur Jack Marling. His company, Lumicon, now offers a line of light-pollution filters tailored for different types of observing. A few years later, optical designer Al Nagler introduced his wide-field eyepiece. Observers found the high-power 82° field of view so addictive that they were willing to pay premium prices for one.

big **low-cost** telescopes at **long** last became a **reality.**



Designed in 1980, the Tele Vue Genesis grew from a need to test Tele Vue's wide-angle, flat-field eyepieces. Tele Vue



Rick Harris shows his classic 10-inch f/5.6 Dobsonian at the 1987 Texas Star Party. The classic design includes a twist, an equatorial platform that provides twenty minutes of tracking. Richard Berry

Digital setting circles are common today, but in the early 1980s, we only dreamed about them. I first saw "digital" circles at Riverside where amateur astronomer Dennis Donnelly was observing bright stars in full daylight with his 8-inch f/8 Dob. Dennis had wrapped plastic-coated measuring tape refills around the bearings of his telescope, so you could read off where his telescope was pointing in inches. Using a "newfangled" scientific calculator, he converted right ascension and declination to altitude and azimuth, altitude and azimuth to inches, and then used inches to point his telescope.

As the Dobsonian revolution swept across America, it turned amateur astronomy upside-down. Telescopes with 10- to 17.5-inch apertures became commonplace, and a growing number of 20- to 24-inch Dobs showed up at national star parties. It was a time of experimentation, rapid evolution, and tremendous excitement. Although observers dreamed of still larger apertures, it slowly became clear that the original Dobsonian design was too heavy and bulky for really large telescopes. A larger, lighter, and more compact Dobsonian was needed.

In the autumn of 1982, amateur astronomer Ivar Hamberg exploded a bombshell over the world of amateur telescope making with his two-page article about simplifying the Dobsonian, replacing the heavy solid tube with an airy aluminum truss. The result was a telescope that could be carried in the back of a compact car and assembled at a dark-sky observing site by one person.

Amateur telescope makers who saw Hamberg's article realized that this design pointed the way to larger and more portable telescopes. This triggered a second Dobsonian revolution. Amateurs who had never dreamed they would own a telescope larger than 8 inches found themselves building lightweight, portable 17.5-inch Dobsonians.

Although the Dobsonian design had pointed the way to larger telescopes, the same concepts had broad application for more modest instruments. A beginner can build a low-cost 6-inch f/8, a solid 10-inch f/6, or a classy 6-inch f/15 refractor solidly mounted on a tall, Dobsonian tripod using simple materials and hand tools.

Dobsonians continued to get better. Refinements to the basic design included quick-acting clamps that allowed drop-in truss tubes, detachable wheelbarrow handles, enormous side bearings, an ultra-lightweight upper end, and low, sturdy rockers. These are the details that improved upon Dobson's original design. They made large aperture telescopes easy to transport, set up, and use.

I can only imagine how Steve Walther would have reacted to one of today's big Dobsonians. Steve was an excitable person, and I imagine him scrambling up the ladder, leaning toward the eyepiece, and crying out with delight at the subtle colors in the Orion Nebula, the delicate filaments of the Veil Nebula, or the dim glow of an incomprehensibly distant cluster of galaxies. ◼

Richard Berry was the editor-in-chief of Astronomy *for 16 years. He now writes astronomical books and software full time.*

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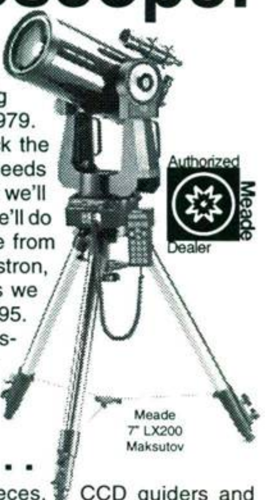

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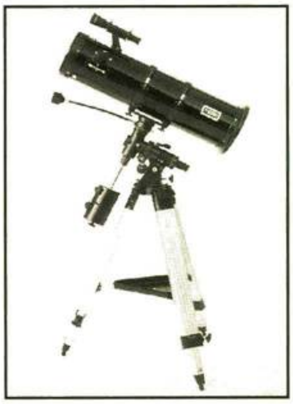

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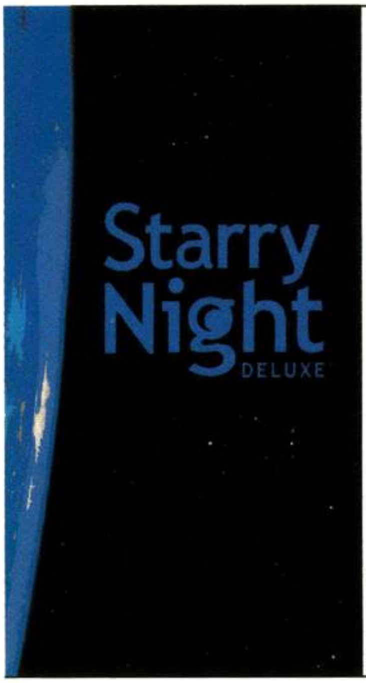

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Film Noir, Pixel Perfect

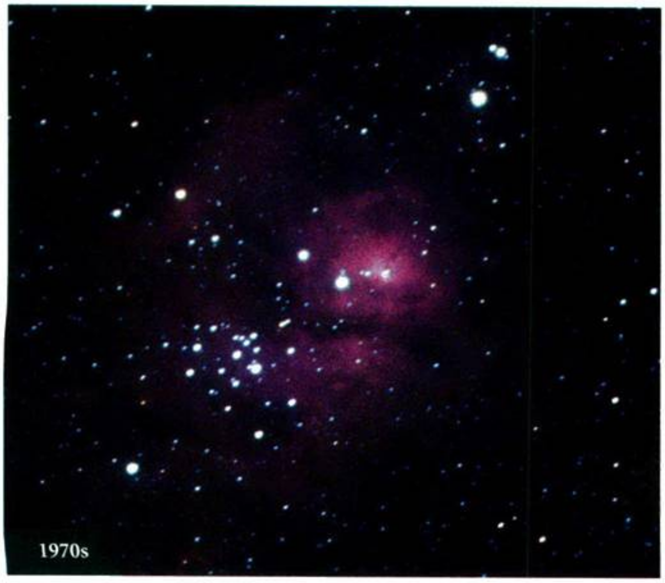
A handful of the world's most skilled astrophotographers reflect on the renaissance in astrophotography.

by Phil Harrington

Anyone can buy photos of the Orion Nebula or download an image of Saturn from the Internet. It's easy. But nothing compares to the exhilaration of taking your own photograph of an eclipsed sun or a brilliant comet like Hyakutake or Hale-Bopp with your own camera and telescope. I think astrophotography is one of the most exciting parts of amateur astronomy. You can make the sky your Sistine Chapel and become a Michelangelo. Of course, the tools of astrophotography — the films, the cameras, the clock drives, and the telescopes themselves — have been transformed in 25 years. So in keeping with the silver anniversary theme of this issue, I asked some of the world's most skilled astrophotographers to recap the renaissance in astrophotography and sketch how additional advancements, like CCD imaging, can contribute to the enjoyment of astronomy.

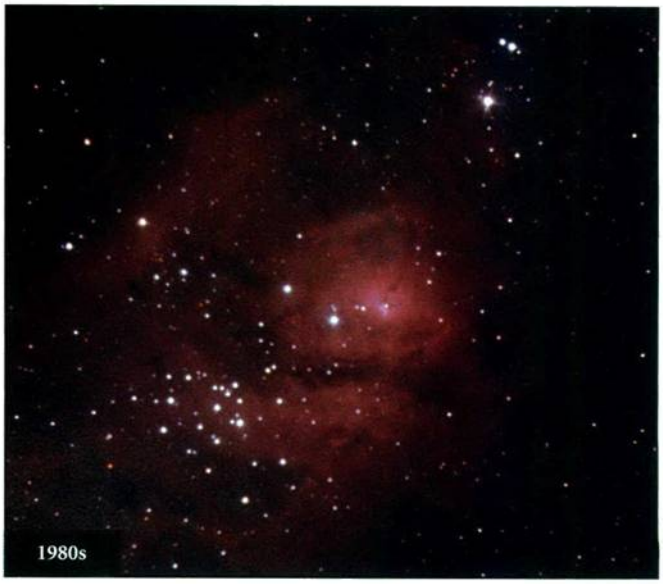
Film is our paint, but few films suited astrophotographers 25 years ago. Popular films of the day included High Speed Ektachrome and GAF 500 color-slide films and Tri-X and 2475 black-and-white film. Color-negative films were all but ignored due to their slow speeds. "When I started trying high-resolution

Lagoon Nebula (M8) 1970s: 5-inch SCT at f/5, Ektachrome 400 film, 40-minute exposure with a cold camera. 1980s: 16-inch f/6 reflector, Konica SRV 3200 film, 12-minute exposure with a cold camera. 1990s: 5.1-inch f/6 apochromatic refractor, hypered Fuji 800 film, 30-minute exposure.



1970s

Bill Iburg



1980s

Jack Newton

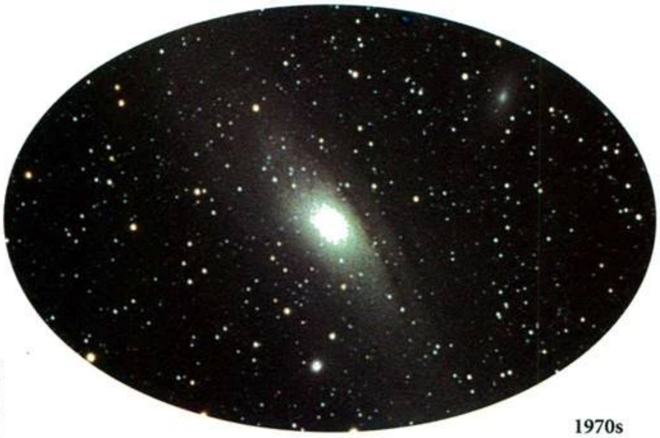
Jerry Lodriguss

stuff in the early 70s, the film of choice was high-contrast copy film — really ghastly but it worked with some darkroom prodding," says renowned planetary photographer Don Parker of Coral Gables, Florida. "I still have some of it in the freezer. Let me know if anyone wants to buy some."

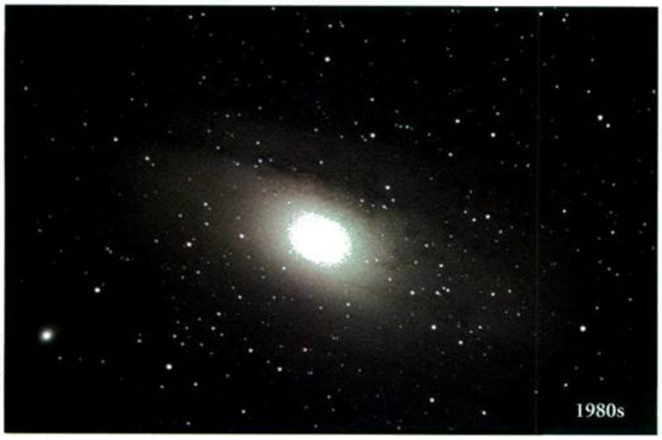
A common problem with many of those films was "reciprocity failure," a film's saturation point after which no further light will be recorded regardless of length of exposure. Many amateurs found that special, black-and-white spectroscopic films, such as Kodak's 103a-O and 103a-E, had far better reciprocity properties, but they also were slow and grainy. As a result, photographers had to make exposures of an hour or longer and guide their scopes all the while.

Getting Pushy with Film

Decades ago, astronomers discovered that film exposed on cold, dry nights was faster than when it was exposed on warmer evenings. The colder, the better. To increase film sensitivity and decrease reciprocity failure, regardless of conditions, many advanced photographers began using "cold cameras." These specially outfitted cameras held chunks of dry ice to lower the film's temperature to about –25° C. Results were impressive, as was the inconvenience.

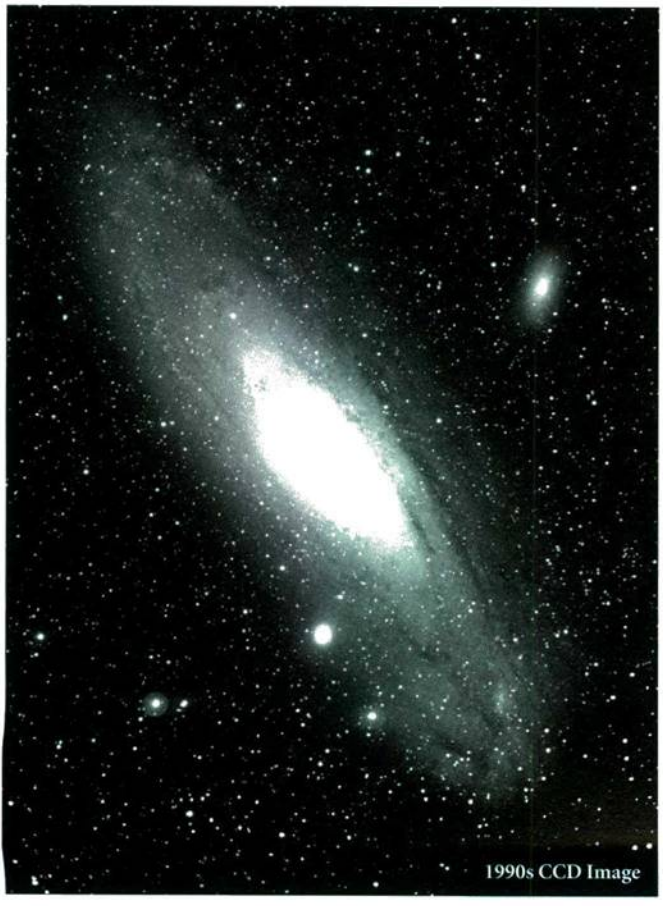


David Healy



Mike Mayerchek

M31: The Andromeda Galaxy 1970s: 8-inch f/10 SCT, Fuji 100 film, 25-minute exposure. 1980s: 14-inch SCT at f/5.5, 3M 100 film, 50-minute exposure. 1990s CCD image: 4-inch refractor at f/4.5, IMG 1600 CCD camera, composite of two 6-minute exposures. 1990s film image: 5.1-inch apochromatic refractor at f/6, hypered Fuji Super HG 400 film, composite of two 45-minute exposures.



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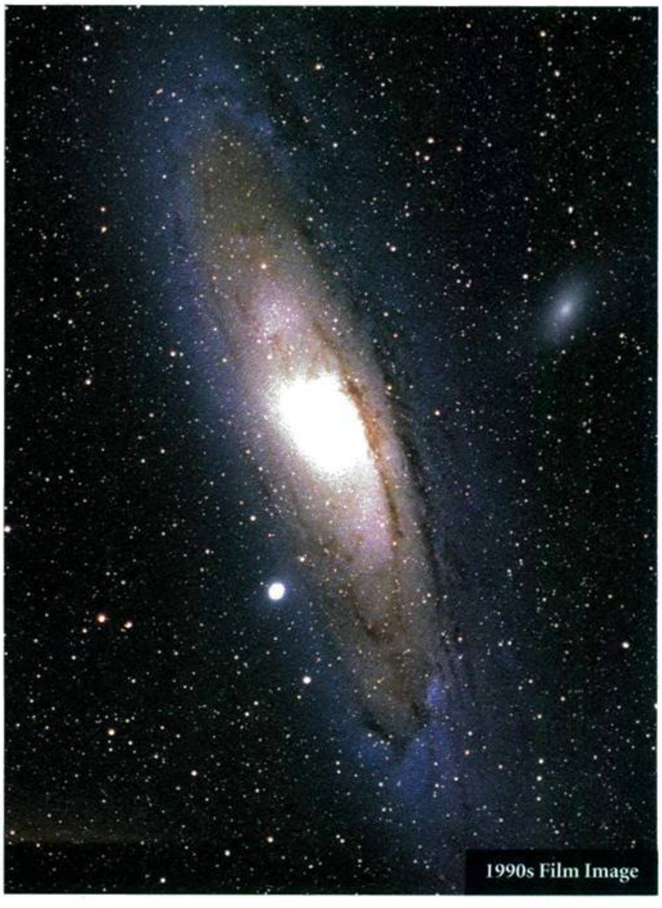


Jerry Lodriguss

Carl W. Weber

Comets 1970s: Comet West, 50mm lens, 5-minute exposure. 1980s: Comet Halley, 5.5-inch f/3.6 Schmidt camera, Konica 1600 film, 20-minute exposure. 1990s: Comet Hale-Bopp, 6-inch refractor, Kodak PPF Pro 400 film, composite of 10- and 12-minute exposures.

Scott Hicks

Charles Scovil

Astrophotographers embraced film hypersensitization in the 1980s. This involves baking a roll of film for several days in a special oven containing "forming gas," a combination of 92 percent nitrogen and 8 percent hydrogen. Hydrogen gas was discovered first to be superior among gases in its ability to penetrate semiporous materials, such as the three emulsion layers of color film. However hydrogen added slightly more speed to the blue, upper layer of color film than the lower layers, resulting in a blue-color shift. That problem was solved with the addition of nitrogen to the forming gas.

The results with forming gas were fantastic, but the process was expensive and the hypering effect was lost after one month. Today's most popular fine-grained, low-reciprocity-failure film is Kodak's Technical Pan 2415, which is meant to be hypered at home for deep-sky astrophotography or left unhypered for planetary and lunar photography. "Today, what a change," says San Antonio, Texas, photographer Robert Reeves. "Color films are astonishingly fast and extremely sensitive to the delicate and faint structure of the cosmos that the human eye cannot even guess exists."

Latest Cameras Not Automatically Better

If film is our paint, the 35mm single-lens-reflex camera is our canvas and frame. This camera allows photographers to view directly through the lens, ensuring proper composition. In 1973, astrophotographers were using manual classics like the Nikon F, Canon FTb-QL, Minolta SRT-101, Pentax Spotmatic, and Miranda G. They had fully mechanical lens and shutters settings. Batteries powered only their built-in, match-needle exposure meters. Cameras have evolved greatly in the past 25 years, but not always in ways that benefit astrophotographers.

Today, cameras feature fully automated exposure control, focusing, and flash. These electronic marvels are not designed for routine 30-minute exposures. Battery power keeps shutters open during those long exposures, a feature that quickly exhausts batteries during a series of shots. Expensive batteries run out of juice after only a roll or two of film.

Stars can confuse automatic cameras, causing them to shift their focus in mid-exposure. And always-armed electronic flashes frequently blind people at star parties when the shutter is triggered and the flash goes off. The new "advanced" point-and-shoot cameras are even worse.

Telescope Improvements

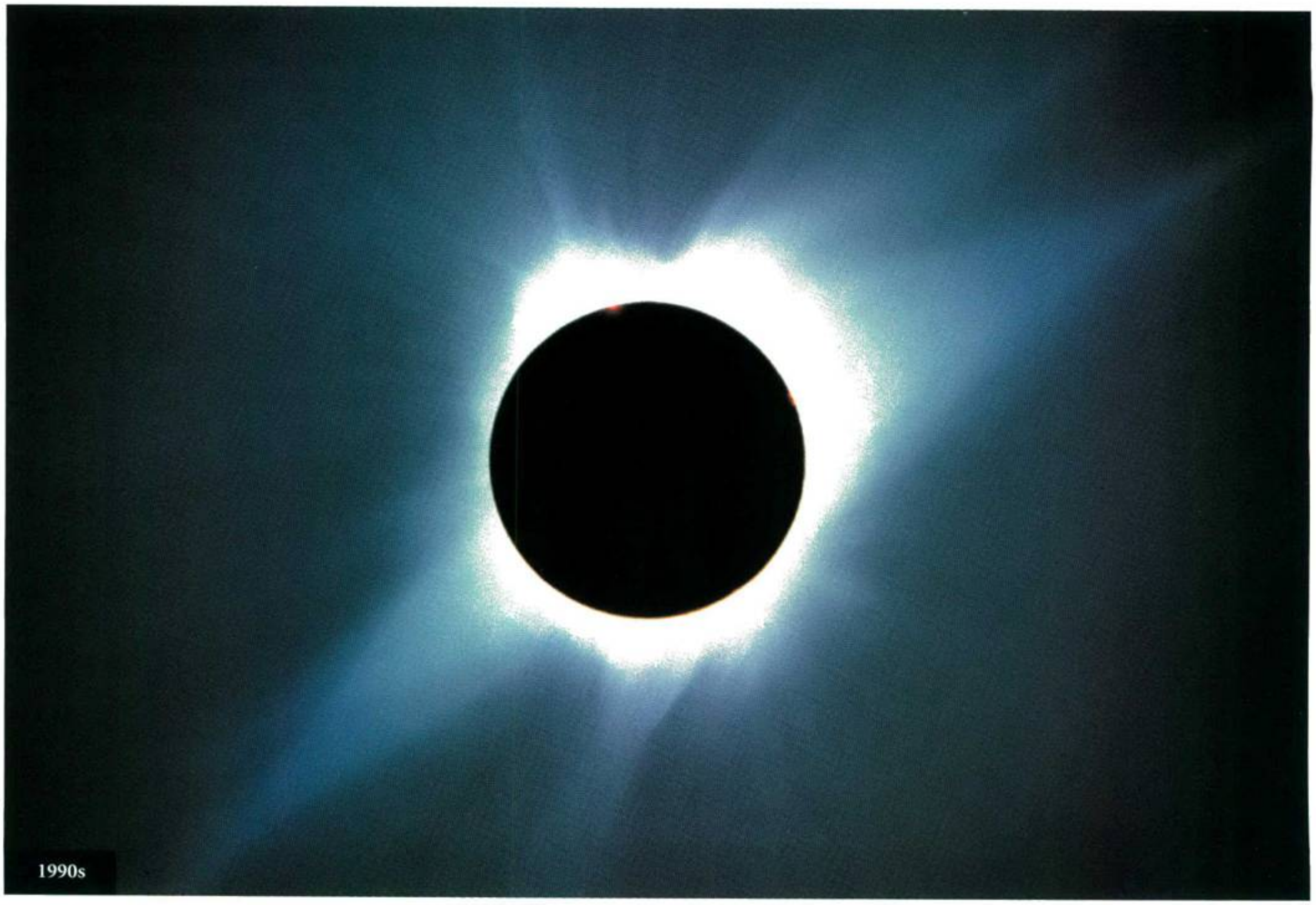
Like many of his contemporary astrophotographers, Robert Provin of Northridge, California, co-author of *A Manual of Advanced Celestial Photography*, used to make his own custom equipment. Not so today. "One of the biggest differences between astrophotography today and 25 years ago is the availability of off-the-shelf equipment that can be used directly for astrophotography," he says.

Astrophotographers struggled in those early days with heavy equatorial mountings and long, unwieldy telescope tubes. But with the 1970 introduction of the Celestron 8 Schmidt-Cassegrain telescope, which was coupled with a

Camera and Film Tips

Many astrophotographers still favor older models made by Nikon, Canon, Pentax, and Minolta. "The serious astrophotographer craves the very cameras that were new when *Astronomy* was first published a quarter century ago," says Robert Reeves of San Antonio, Texas. Astrophotographers today would add models in the Olympus OM family, the newer Nikon F series, the Pentax K1000 (the only fully mechanical camera still manufactured), and a few exotic brands.

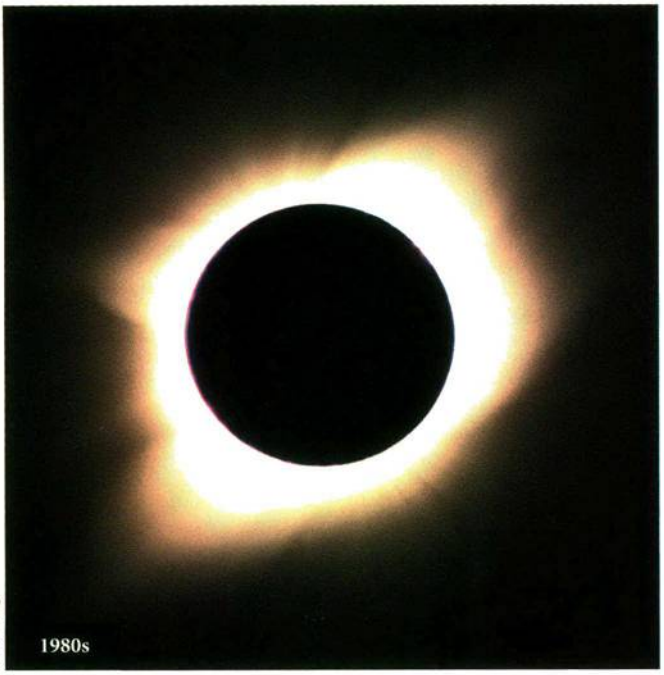
Today's films have superior resolution, lower reciprocity failure, faster speeds, and finer grain than anything on the market in 1973. Some of the finest films for long-exposure astrophotography include color-negative films — Fujicolor Super G Plus 400, Super G Plus 800, and Super HG 1600, Kodak's Pro 400 (PPF), and Konica SR-G 3200; color slide films — Kodak Ektachrome 100 Professional, Elite II 400, and Ektachrome P1600, and Fujichrome Provia 100 and Provia 1600; and black-and-white films — Kodak Tech Pan 2415, T-Max 100, and T-Max 400.


1990s

Roland and Marj Christen

compact fork, the era of the mobile telescope began. The SCT was made so that a camera was easy to attach.

Telescopes and their accessories have continued to improve. Optical coatings make it possible to squeeze more light and better resolution from telescopes. Manufacturers continue to redesign and refine mountings to support the additional weight of a camera, piggybacked lenses, and other attachments. The mounts, often built with advanced materials, are light for easy setup and sturdy to dampen vibrations.



David Wing

Total solar eclipse **1970s: 3.5-inch f/14 Maksutov-Cassegrain, Kodachrome 64 film. 1980s: 3-inch f/16 refractor, Fuji 400 film. 1990s: 5.1-inch f/8 apochromatic refractor, Ektar 25 film, 8-second exposure.**

The pre-clock drive era was one in which observers were required to remain glued to a telescope's eyepiece to guide it continually. Drive motors, powered by alternating current, freed astrophotographers from that laborious task. Battery-powered autoguiders completed the emancipation by permitting astrophotographers to travel to dark, remote areas with telescopes that automatically track across the sky. "The autoguider was a godsend," says Chuck Vaughn of Fremont, California. "Before, all my photos were limited to about one hour because physically I couldn't guide longer than that."

The personal computer has made it possible to enhance photographs digitally. Photographers can increase or decrease contrast, make a dim image bright or a bright image dim, adjust color or even add color, and combine images to create montages. These feats are difficult or impossible to achieve with the conventional darkroom techniques available to most amateur photographers.

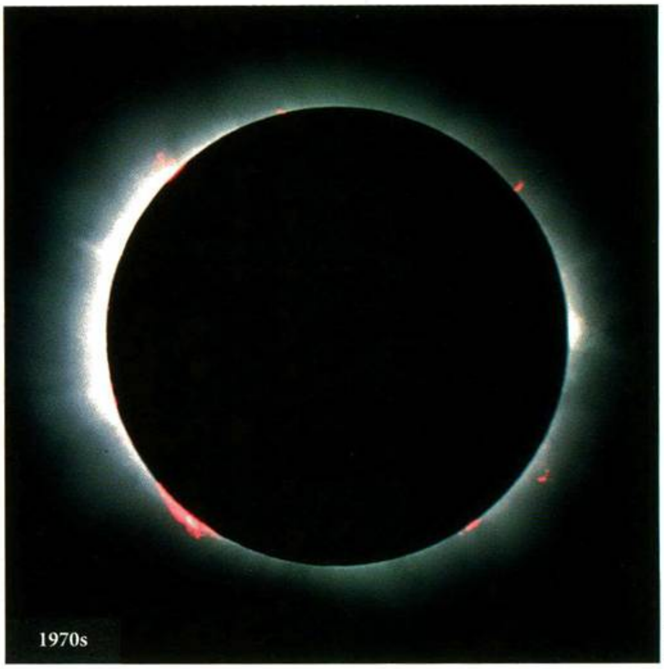
CCD and Deep Space

Of all the advances available to amateurs, none has changed the art of astrophotography more than the affordable charge-coupled device (CCD). It uses a silicon chip made up of thousands of light-sensitive areas called pixels that convert the light they receive into electrons during an exposure. At the end of the exposure, each pixel converts its stored electrons into a number, then downloads that result to a computer. The computer paints an image — by the numbers. The devices are so efficient that a 30-second CCD exposure is equivalent to a 30-minute film exposure.

Computer processing of CCD images can nearly eliminate the effects of light pollution, making it possible to make great deep-sky images from within cities. And to make them even more enticing, many modern CCD cameras include a built-in autoguider. "The CCD revolution has allowed me to convert the darkroom into a much needed kitty litter storage facility and has permitted me to perform image processing techniques in seconds on my computer rather than hours in the darkroom," says Parker. "And for a fraction of the cost."

Once, only professional astronomers at the world's largest observatories used CCD imagers. Today you not only can buy one, you can buy one that will outperform the finest professional CCD available only a few years ago. In fact, some amateurs conduct world-class astronomical research from their backyards with their CCD equipment. "For me, CCDs have completely revolutionized what can be done in astrophotography," says George Viscome of Lake Placid, New York. "They have made it possible for amateurs to take an immense step from simply taking aesthetically pleasing pictures to gathering useful scientific data." Viscome himself has discovered 40 new asteroids with his CCD equipment.

Will CCDs doom film? Hardly, says Jason Ware of Frisco, Texas. "When CCD imagers first came out, everyone said film would be dead in five years. Well, it is now more than five years later, and everyone continues to predict that film will be dead in five years." Whether you choose film or CCD, you can paint your own version of Vincent van Gogh's *The Starry Night*. Imagination and creativity, not great sums of money, are needed. And the universe is an inviting subject, posing every clear night of the year. ■



Alan Dyer

Phil Harrington is a frequent contributor to Astronomy *and author of several books on astronomy, including* Star Ware.

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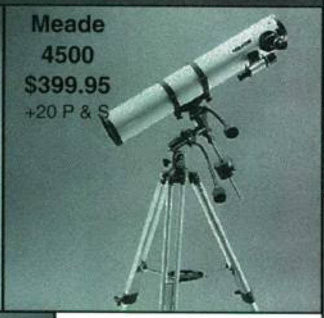

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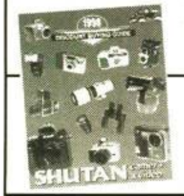

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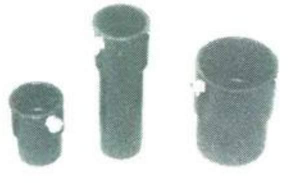

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Magellan computer; specify Dob. or Eq. ($15 ship)	$295
LUMICON 1¼'' UHC or O-III Filter	$99.50

Vinyl covers to keep dust-free (2 req.) for 6'' - **$10**; for 8'' - **$15**; for 10'' - **$20**; for 16'' - **$35**

SKY VECTOR™ $299!!

Includes Computer, Encoders, Hardware

LUMICON ACCESSORIES

LUMICON, Livermore, CA 94550 (925) 447-9570 FAX (925) 447-9589

LOW PRICE—from $299

LUMICON SKY VECTOR FEATURES:

- "GUIDE" mode leads you to object
- Digital right ascension readout to 1 min.
- Digital decl. readout to 10 arc-min.
- 4000 pulse (0.09° accuracy) encoders
- Polar alignment ***not required!***
- Motor drive ***not required!***
- Just sight two stars to align!
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080.
- **No need** to enter latitude, longitude, etc.

SKY VECTOR I™ $299

NEW! With over 220 object memory including the 110 Messier and 58 best NGC objects.

SKY VECTOR II™ $349

Over 3600 objects! — Also includes planets and full visual descriptions.

NGC SKY VECTOR™ $439

12,000 Objects!— PC Serial Port

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LUMICON

NGC SKY VECTOR with IDENTIFY (Sky Tour) mode, 12,000 object memory including the corrected RNGC catalogue, IC catalogue, P&K planetary catalogue, & much more!

Specify Telescope Type: Meade 2045, 2080, 2120, C-8, C-11, Odyssey 8, 10, 13, 17½, Alt-Azimuth, Meade 6-16'' Dobsonian.
Ultima 8, 9¼, 11 **add $25**, C-14 **add $75**

COMA CORRECTOR

Coma 1 inch off-axis 17½'' f/4.5

Same field with LUMICON coma corrector; smaller, more numerous stars.

This computer-designed LUMICON 2'' lens reduces coma and flattens the field for both viewing and photography. **It threads into LUMICON 2'' EASY-GUIDERS for effortless installation.** This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Clear aperture = 1.8''.

LUMICON 48mm Coma Corrector/Field Flattener Lens	$285.00
LUMICON 2'' EASY-GUIDER .	$189.50
2'' EASY-GUIDER (Mamiya 645)	$239.50
2'' Adapter for Pentax 6X7 ...	$129.00
2'' Adapter for Hasselblad .	$229.00
2'' Adapter for Bronica SQ-A	$175.00
2'' Extension for viewing ...	$26.00

2'' DELUXE BARLOW

1.8x Multiplier Lens (2'' Barlow)

LUMICON 1.8x Multiplier Lens (2'' Barlow)	$259.00

LARGE UV/DUST SEAL

Protect the optics of your 8-14'' Schmidt-Cassegrain with a UV/Dust Seal. Simply thread it onto the rear cell, then attach all normal accessories. The large size fits Meade 2120, Celestron-11 and -14 & has a high quality multi coated (removable) 72mm UV filter.

Deep-Sky Filter/Dust Seal for C-8, 2080 .	$199.50
UV/Dust Deal for Celestron C-8 ...	$39.00
UV/Dust Seal for Meade 4''—8'' ...	$39.00
UV/Dust Seal (lg.) for Meade 10''—12''	$89.50
UV/Dust Seal for Celestron-11, -14 .	$89.50

LOW PROFILE FOCUSERS
New! Thread-on for Odyssey

FROM $69.50

LUMICON® LOW PROFILE FOCUSERS

LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½'' above the telescope tube. Use the 1¼'' or 2'' versions for viewing. Use the 2'' non-rotating focuser for convenient photography with the LUMICON 2'' EASY-GUIDER™.

Select your desired base-plate shape! Coulter Odyssey (thread-on installation), Flat, 7'' OD, 9½'' OD, 12½'' OD, 16'' OD, 21'' OD.

LUMICON 1¼'' Helical Focuser	$69.50
LUMICON 2'' Helical Focuser 1½'' high	$75.00
LUMICON Non-rotating Helical Focuser	$129.00
2'' Astro Systems focuser, only 2'' high	$139.00
3 handles for non-rotating focuser	$12.95
2''/1¼'' adapter w/48mm filter threads	$20.00
2'' LUMICON EASY-GUIDER	$189.50

LUMICON 50mm, 80mm SUPER-FINDER™

Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat or 50mm, F=200mm coated achromat. Eyepieces and/or star diagonal are extra.

1¼'' 50mm Finderscope **$69.50**, 45° version	$69.50
1¼'' straight-thru 80mm SUPER-FINDER .	$199.50
1¼'' right-angle 80mm SUPER-FINDER ..	$209.50
1¼'' right-angle version, w/star diagonal ..	$239.50
25mm Cross-hair 1¼'' eyepiece (12X)	$59.00
Large mounting rings for 80mm Finder	$55.00
1¼'' Star Diagonal **$49**, Mounting Brackets,	$39.50
1¼'' 45° diagonal for correct left-right views	$49.00

PROTECTIVE DUST COVERS

Protect your valuable telescope optics, eyepieces and accessories with these black vinyl covers. Add $1 shipping. Deduct 10%, 2 or more sets.

1¼'' O.D. plug, seals focuser	4/$2		
2'' O.D. plug	2/$2	3½'' O.D. plug	$1.50
1¼'', 1⅜'' ...	3/$2	7½''	$10
1½''	2/$2	9½'', 10.4''*	$15
2''	2/$2	12½'', 12⅞''* ...	$20
2⅛''	2/$20	15.0'', 15.6'', 16''*	$28
5½''	$6	19'' (DS-16)	$35
*Fits Odyssey		21'' (Odyssey-II)	$35

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LUMICON carries a full line of telescopes and accessories. Fast Delivery, Competitive Prices.

LUMICON FOR HIGH PERFORMANCE

Visit our LUMICON web-site: http://Astronomy-Mall.com/Lumicon

NEW LUMICON MULTIPLE FILTER SELECTOR

ALWAYS GET THE BEST VIEW!

$99
(If ordered with LUMICON filter or filter set)

The New LUMICON Multiple Filter Selector holds up to 5 1¼" LUMICON filters. The sliding bar has a click-stop at each filter position. Now you can instantly select the best filter for any deep-sky object. Cost is $129 or $185 with 1.5X relay lens (for Newtonians). **Save $30 if ordered with filter(s)!**

TELE VUE™

NEW! Bino Vue Binocular Viewer

5X! Powermate boosts magnification 5X **$179**
Ranger 70mm f/6.8 apochromat w/45° diag. **$659**
Pronto 70mm f/6.8 w/45° erecting prism **$889**
NEW! Bino Vue binocular viewer **$899**
Gibraltar mount with ash wood tripod . **$535**
8, 11, 15mm Plossl . **$95**, 20, 25mm . **$105**
32mm Plossl, widest true field in 1¼" . **$125**
55mm 2" Plossl, widest possible field . **$235**
2.0x or 3.0x Tele Vue Barlow Lens **$119**
2" Giant Barlow - 2x **$185**
4.8mm Nagler, 82° field, 1¼" eyepiece **$175**
7mm Nagler, 1¼" eyepiece, 82° field . . **$225**
9mm Nagler, 82° field, 1¼" or 2" **$245**
13mm Nagler, 82° field, 1¼" or 2" **$315**
12mm Nagler, Type II, 82°, 1¼"/2" ... **$295**
16mm Nagler, Type II, 82°, 1¼"/2" ... **$315**
20mm Nagler, Type II, 82°, 2" only ... **$395**
2" Paracorr Visual Coma Corrector . **$259**
15mm Panoptic 1¼", 68° field **$215**
19mm Panoptic 1¼", 68° field **$245**
22mm Panoptic 1¼"/2", 68° **$285**
27mm Panoptic 2", 68° field **$335**
35mm Panoptic 2", 68° field **$365**
TeleVue Warranty may not be valid outside USA.

NEW! ENHANCED ALUMINUM DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3" & 2.1" enhanced aluminum diagonal mirrors & 1¼" star diagonal.

The new LUMICON diagonal mirrors have a special enhanced aluminum coating with a protective overcoating for long life. Visible reflectivity is 94-96% compared to 86-89% for standard aluminum coated mirrors. The extra 5-10% transmission is like adding up to an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32" **$39.50** 1.52" **$45.00** 1.83" **$49.50**
2.14" **$59.50** 2.60" **$75.00** 3.10" **$99.50**

ENHANCED ALUMINUM STAR DIAGONAL

90° star diagonals with 96% reflectivity enhanced aluminum mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1¼" (1.32" mirror) **$99.50**
2" (1.83" mirror)(see photo above) .. **$189.50**

LUMICON FILTERS — BEST IN THE WORLD!

"The LUMICON O-III proved to be our favorite... It gave the greatest contrast gain." ***ASTRONOMY*, February 1991**

AMAZING O-III FILTER™

Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

GREATLY ENHANCED DETAIL

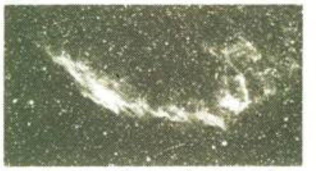
"Consistently performed well on all emission and planetary nebulae. Detail and structure were greatly enhanced in the more than two dozen objects I viewed." ***SKY & TELESCOPE*, July 1995**

BETTER THAN A DARK-SKY SITE!?

"From my light polluted backyard, the view ... was better with the O-III than with any other filter tested. The view was even better than without the filter from a dark-sky site." ***SKY & TELESCOPE*, July 1995**

SEE THE HORSEHEAD!

*"**LUMICON's H-Beta Filter** will show subtle features in emission nebulae that the others fail to reveal. It can't be beat for the elusive Horsehead and California nebulae. . ."* ***SKY & TELESCOPE*, July 1995**



"I CAN SEE THE VEIL NEBULA!"

Rich Zepernick saw the Veil Nebula for the very first time with a **LUMICON UHC Filter**. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*
Rich Zepernick, Cresskill, NJ

DEEP-SKY FILTER™

BEST for Astrophotography!

"Stunning is all I can say," says noted astrophotographer Jack Newton. Great for BOTH color and black and white photography.

BEST WIDE-BAND FILTER!

*"Based on our tests we'd recommend a LUMICON Deep-Sky and Oxygen-III as complementary filters. The LUMICON Deep-Sky Filter clearly had the best contrast for **reflection** nebulae."* ***ASTRONOMY*, February 1991**

Premium*
1¼" LUMICON DEEP-SKY Filter threads into most 1¼" eyepieces **$99.50**
48mm LUMICON DEEP-SKY Filter (1.7" aperture), threads into most 2" eyepieces. Also fits LUMICON EASY-GUIDERS **$199.50**
2" LUMICON DEEP-SKY Filter (1.5" aperture), threads into most 2" eyepieces. Also has male & female camera T-threads for prime focus photography **$199.50**
72mm LUMICON Giant DEEP-SKY Filter (62, 67, 77mm adapter, $10, 82mm $16) **$399.50**
2" Rear Cell Filter, fits SCT's .... Deep-Sky, **$199.50** UHC, O-III, H-Beta, **$199.50**
1¼" LUMICON UHC Filter threads into most 1¼" eyepieces **$99.50**
48mm LUMICON UHC Filter (1.75" aperture) fits most 2" eyepieces **$199.50**
Choice of ***any two*** LUMICON filters (**Save 7%**) .... 1¼" **$185.00**; 48mm **$370.00**
LUMICON H-BETA Line Filter (9mm bandpass at 486nm). For the California Nebula, Horsehead Nebula, and other extremely faint nebulae. **1¼"** .... **$99.50, 48mm** **$199.50**
Oxygen-III Filter for very faint planetary and diffuse nebulae, 11nm bandpass at 496nm and 501nm O-III lines .... **1¼" $99.50; 48mm $199.50**
LUMICON Comet (Swan band) Filter .... **1¼" $99.50; 48mm $199.50**
Telephoto lens adapter for 2" or 48mm filter. Select 46, 49, 52, 55, 58mm **$7.95**
Universal adapter for 1¼" filters. Adapts the 1¼" filters to any 1¼" eyepiece **$19.50**
Universal adapter for 48mm or 2" filters. Allows use of any 1¼" eyepiece **$25.00**
**Premium filters are currently the best in the world. All Lumicon filters include individually measured transmission data.*

ADJUSTABLE PIGGYBACK MOUNT

The LUMICON adjustable piggyback mount is ideal for telescopes of 6-16" aperture. It permits **both** vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER™, large telephoto lenses and small telescopes up to about 5 lbs.
LUMICON Adjust. Piggyback Mount $59.50
Specify telescope size: 6", 8", 10", 11", 14", 16"

H-ALPHA PASS FILTER

Yields spectacular contrast gains in B&W photograph with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the LUMICON Deep-Sky (DS) Filter.

Specify Lens Size	H-Alpha	(DS)
46, 48, 49mm	$59.00	$199.50
52, 55, 58, 62mm	$69.00	$199.50
67, 72, 77mm	$79.00	$399.50
82mm (77mm + adapter)	$89.00	$415.00

Hypered 2415 film, 36 exp .. **$11.95, $3/$32**

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DEEP-SKY ASTROPHOTOGRAPHY

SR-V 3200 NEW FILM

FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15x film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

†U.S. Patent 4,473,636

MAKE YOUR OWN HYPERED FILM

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$325**

MODEL 600 HYPER-KIT (See photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$395**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller ... **$595**

Temperature controller for any HYPER-KIT **$75**

Electric Vacuum Pump, Model R-10 **$325**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright guide-stars. †U.S. Patent 4,448,500
Specify Camera and Telescope type.

NEWTONIAN EASY-GUIDER™

Full aperture. Installs in seconds. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER **$189.50**
48mm Coma corrector/field flattener .. **$285**
3X Relay Diagonal (see photo) **$99.50**
Illuminated reticle eyepiece, pulsed . **$119.50**
Guider for Hasselblad **$489,** Mamiya 645 **$259**
Pentax 6X7 **add $129;** Pentax 645 **add $149**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Cynamax-8. Includes 50mm achromatic lens for f/5.8 operation—3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER **$249.00**
Adapter for Hasselblad **$299,** Mamiya 645 **$98**
Pentax 6X7 **add $129;** Pentax 645 **add $149**

GIANT EASY-GUIDER™

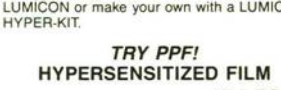
For Celestron-11, C-14, and the 10-12" Meade. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER **$395.00**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER (SAVE $20) .... **add $179.50**
Adapter for Hasselblad **$399,** Mamiya 645**$149**
Pentax 6X7 **add $139;** Pentax 645 **add $159**

WHAT DO YOU NEED?

1. **Illuminated reticle eyepiece** .... **$119.50** Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, pulsed.
2. **Cable release** for long exposures . **$9.95**
3. **Declination motor** (state telescope type) **$109**
4. **Dual-axis drive corrector** for telescope. This should be part of the telescope when purchased. Call LUMICON for details.
5. **LUMICON EASY-GUIDER** (selection to left) .
6. **LUMICON 48mm DEEP-SKY FILTER $199.50** This is essential for highest possible contrast. Contrast is boosted up to 3X for ***both*** color or black & white photos. The 3 photos in this ad showing the Helix Nebula, Horsehead Nebula and Veil Nebula were all made using a LUMICON 48mm DEEP-SKY FILTER.
7. **Hypersensitized film.** Purchase from LUMICON or make your own with a LUMICON HYPER-KIT.

TRY PPF! HYPERSENSITIZED FILM



HYPERED FILM IS 2-10X FASTER!

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.). ***No C.O.D.s.***

Film Type, 35mm	Exposures	Price
Kodak PPF-400, THE BEST!	36	$14.95
2415, Ultra-fine B&W, red sens.	36	$11.95
SR-G3200, fastest of all, color neg	24	$13.95
Kodak Gold 1000 fast, fine grain	12	$13.95
Fuji G800 fine grain color neg.	24	$13.95
Ektachrome 1600, fast slide film	24	$14.95
Fujichrome RD100, fine grain slide	24	$12.95
D-19 B&W Developer	1 gal.	$8.50

LOOKING AHEAD

AUGUST

WE HAVE BEEN RECEIVING more notices of astronomy-related events each month, often accompanied by a note claiming a substantial increase in attendance when an event had been listed in *Astronomy*. That's good news — it means people are searching this column for activities taking place in their part of the country, and often, planning vacations around specific star parties or conventions away from home.

What's missing, though, is photos from many of the events we list. When choosing the photo for this column, we look for a crisp, clear image that, in one shot, encompasses the overall feel of the event — the location, people, activities, equipment, and skies that will entice our readers to attend. Photos do not have to be from large, nationally-recognized gatherings; small, local events can be just as scenic. So please, when sending in your notices of events, feel free to drop in a few photos — we'd love to see them.

THROUGH SEPTEMBER

Summer Public Observing

▶ Naperville Astronomical Association's Observatory, Springbrook Water Reclamation Center, Naperville, Illinois. Wednesdays, 7:30 p.m. Contact George Simon, Jr., (708) 983-5029.

JULY THROUGH AUGUST

Astrophoto Exhibition

▶ National Academy of Sciences, Washington, D.C. Exhibition by famed Australian astrophotographer, David Malin. Free. Contact Fredrica Wechsler, (202) 334-2436.

AUGUST 1, 12, 29

Hurricane Ridge Star Parties

▶ Olympic National Park, Port Angeles, Washington. Hosted by the National Park Service and Port Angeles High School Astronomy Club. Contact John Gallagher, (360) 452-0260 (day) or (360) 452-7764 (eve.); e-mail, jgalla@orca.esd114.wednet.edu.

AUGUST 5

Midwest Amateur Astronomy Forum

▶ Purdue University Calumet, Hammond, Indiana. Sponsored by the Calumet Astronomical Society. Free. Guest speaker, John Dobson. Contact Nick Zivanovic, (219) 931- 8790; e-mail, info@casonline.org; website, http://casonline.org.

Mile-high Mt. Kobau in British Columbia draws more than 150 dedicated deep-sky enthusiasts.

Alan Dyer

AUGUST 12

Free Public Star Party

▶ Ralph A. Worley Observatory, south of Shreveport, Louisiana. Sponsored by the Shreveport-Bossier Astronomical Society. Contact Cran Lucas, (318) 797-1524, or visit the society's website at http://www.lsus.edu/nonprofit/sbas/.

AUGUST 15–23

Mount Kobau Star Party

▶ Okanagan Valley, British Columbia, Canada. Contact Kobau Star Party 1998, c/o Caroline Wallace, P. O. Box 20119 TCM, Kelowna, BC V1Y 9H2; phone/fax, (250) 498-3244; e-mail, cwallace@vip.net; website, http://www.bcinternet.com/~mksp.

AUGUST 18–23

Astroblast

▶ Oil Region Astronomical Observatory in Two Mile Run County Park, Franklin, Pennsylvania. Contact John O'Hara at (814) 677-3972; e-mail astroblast@oras.org; or write ORAS, P. O. Box 351, Reno, PA 16343.

AUGUST 20–22

Southern Idaho Regional Star Party

▶ Bruneau, Idaho. Sponsored by the Boise Astronomical Society. Contact Richard Beaver, (208) 377-5220; e-mail, rjb@rmci.net; website, http://www.isidaho.com/bas.

AUGUST 20–23

Weekend Under the Stars

▶ Foxpark, Wyoming. Contact Marty Curran, (307) 635-5944; e-mail, mcurran@sisna.com; website, http://users.sisna.com/users/mcurran/.

AUGUST 21–22

Montana Starwatch

▶ Ruby Reservoir, near Virginia City, Montana. Sponsored by the Southwest Montana Astronomical Society. Contact Mike Murray, Museum of the Rockies, 600 W. Kagy Blvd., Bozeman, MT 59717; (406) 994-6891; e-mail, ammmm@montana.edu; website, http://www.montana.edu/ smasweb/.

AUGUST 21–22

Susquehanna Summer Star Spectacular Star Party

▶ Chestnut Hill Airport, near Duncannon, Pennsylvania. Contact Joe O'Haren, e-mail, joharen@paonline.com; ASH Starline, (717) 938-6041.

(See "Looking Ahead", p. 127)

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Earth
IN THE AUGUST ISSUE

THE REAL GENESIS FLOOD
In Black Sea mud, scientists have found signs of a flood of biblical proportions. Sparks fly over the controversial claim.

NO BONES ABOUT IT
Sean Carroll is chasing legs. Using tools of molecular biology, he may have unlocked the genetic toolbox for building limbs.

CARNIVORE COLONIZERS
Plants and plant-eaters were supposed to be the first life-forms to hit land. But in Australia, one paleontologist has found that the first land creatures actually had jaws and teeth made for killing.

To get your copy of ***Earth***, on sale July 7, visit your local bookstore or newsstand or call
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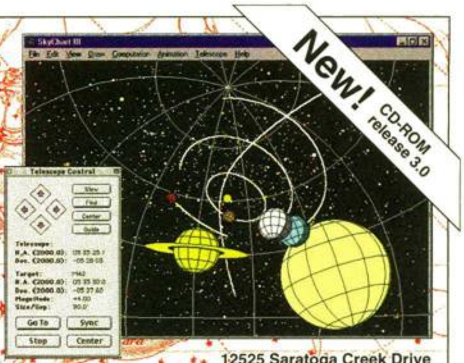

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Astro-Physics 1200GTO, 900GTO, 600EGTO German Equatorial Mounts with Servo Drive, Go-to Keypad, DigitalSky Voice™ Software

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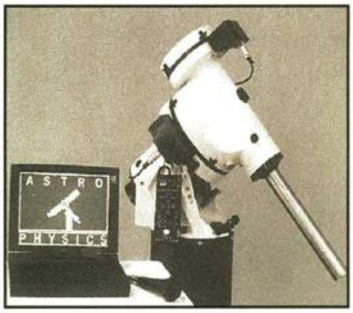

1200GTO German Equatorial with Servo-Drive, DigitalSky Voice™ (Laptop not included)

- Zero-cogging, precision servo-motor with microprocessor control to an accuracy of ± 0.05 arc seconds per step
- Fast-slewing at 5 degrees per second
- Accurate sidereal motion ± 5 arc sec. periodic error
- Portable, very solid, vibration-free construction
- RA/Dec axes come apart without tools for easy transport
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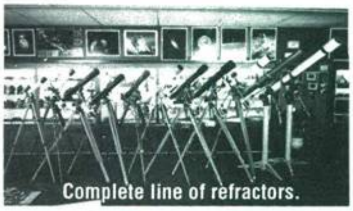

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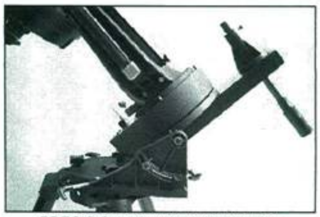

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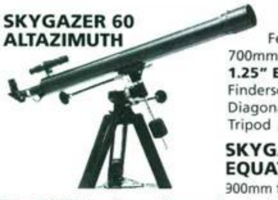

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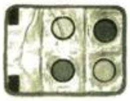

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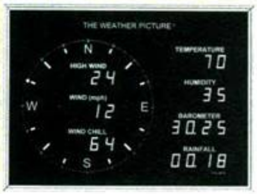

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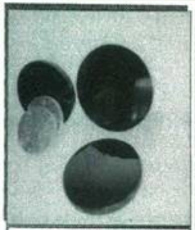

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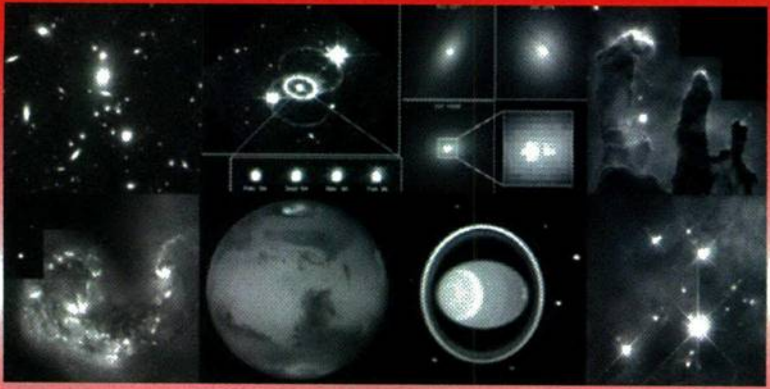

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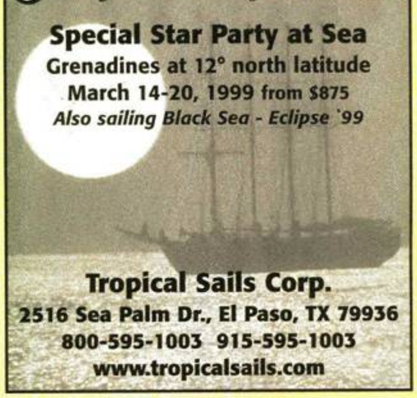

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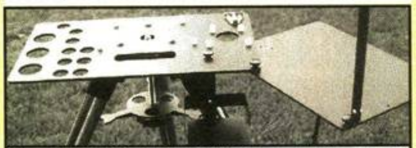

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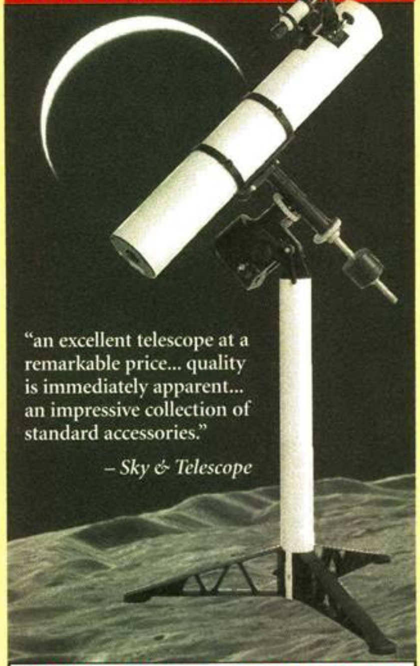

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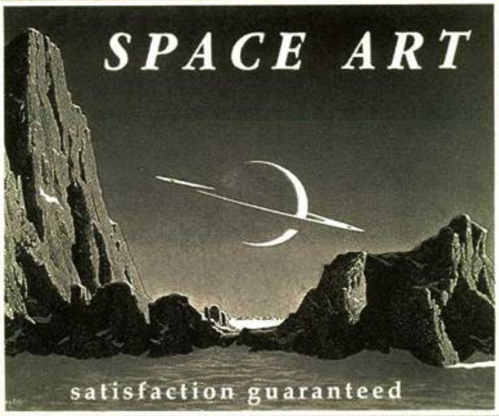

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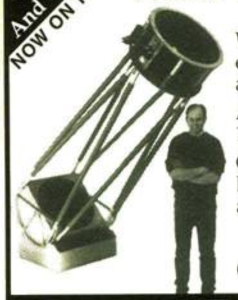

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PHOTO CONTEST

Photo Finish

Astronomy salutes the winners of our 25th Anniversary Photo Competition

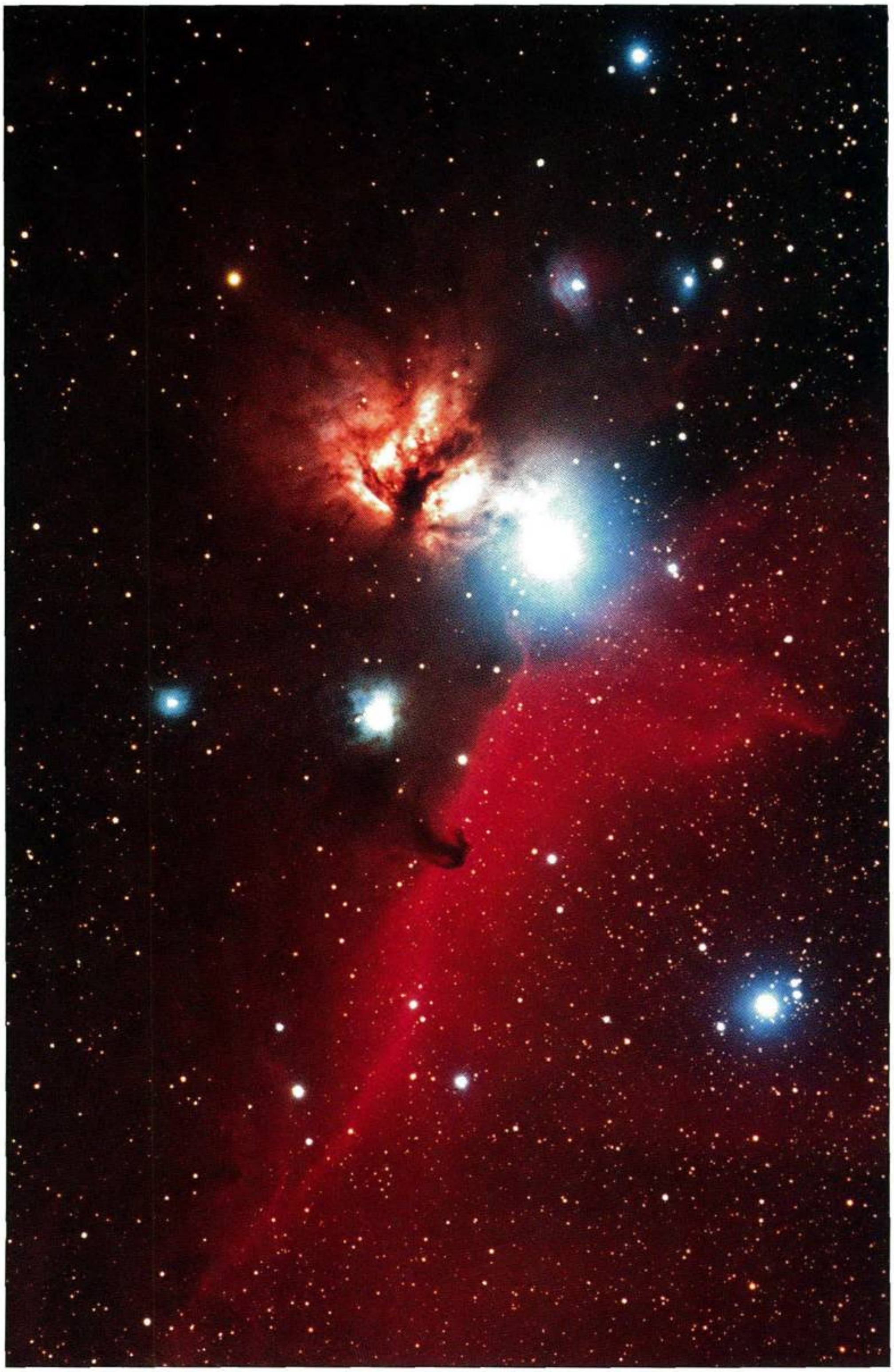
▶ We've become so accustomed to seeing magnificent astrophotos vying for publication in the pages of *Astronomy* that it's easy to take for granted the patience and skills that are required to generate such excellence. A few of the hardships astrophotographers endure: late nights, hours behind the camera, and temperatures into which only a polar bear would venture. Some photographers submit photos for years before seeing their work in print.

This month we dedicate the pages of Hot Shots to the winners of *Astronomy*'s 25th Anniversary Photo Contest. You will see some familiar names among the winners, but most are fresh. These photographers have learned that many factors contribute to a great astrophotograph.

Many beautiful photos, both electronic (Division 1) and film (Division 2), were submitted. Within these divisions were three categories: deep space, solar system, and unique events.

Oh, and be sure not to miss what we affectionately call our "Tot Shots." The winners of our children's photography contest aren't really tots at all — these kids, ages six to 16, wowed us with remarkable levels of skill and expertise. Check out their photographs on page 146–47; we think you'll be as impressed as we were.

– Patricia A. Kurtz,
Photo Editor

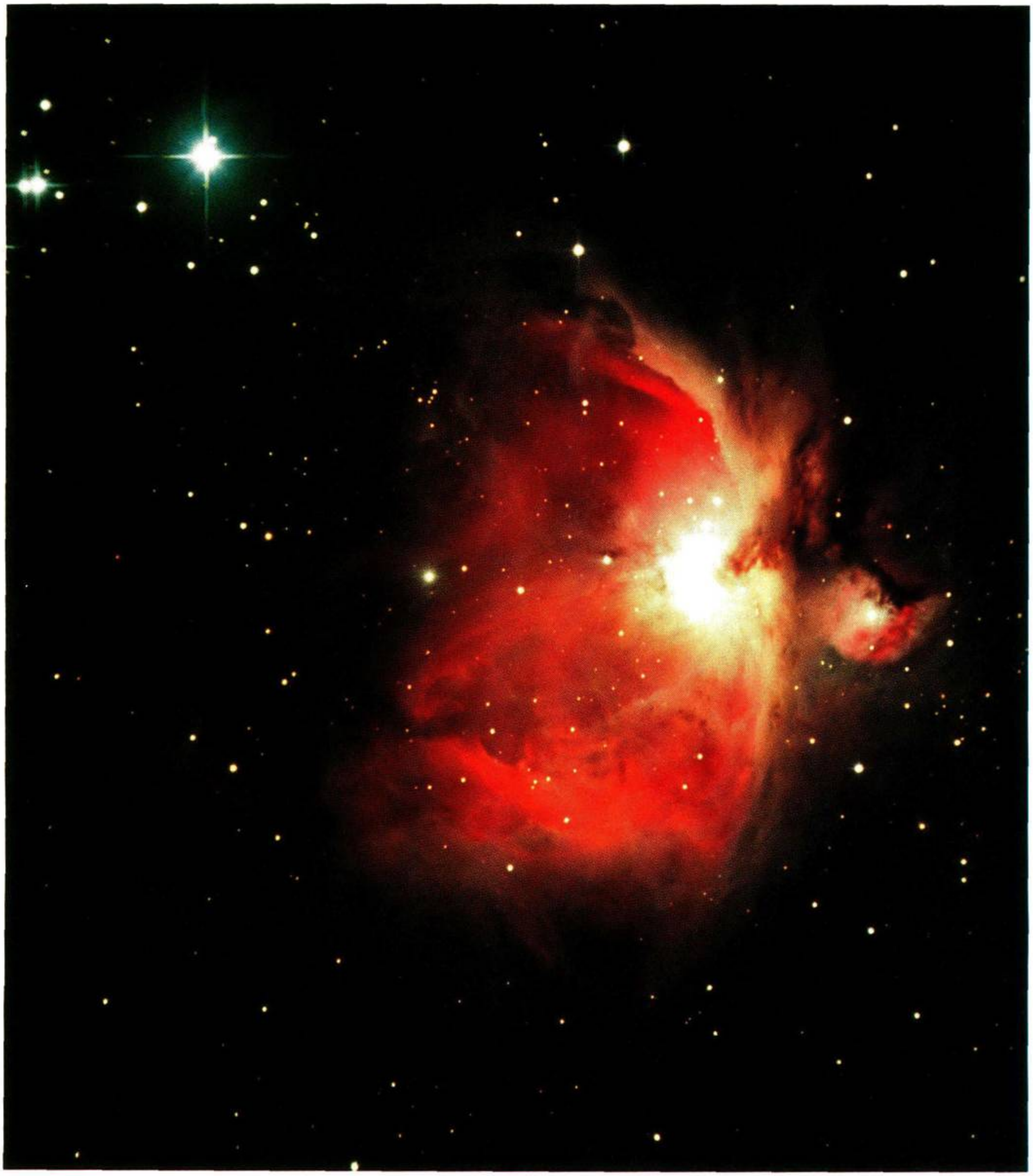


The Horsehead Nebula

Mike Fiest

FIRST PLACE, DIVISION 2: DEEP SPACE

6-inch f/7 refractor, hypered Kodak PPF 400 medium format film, composite of two 60-minute exposures.

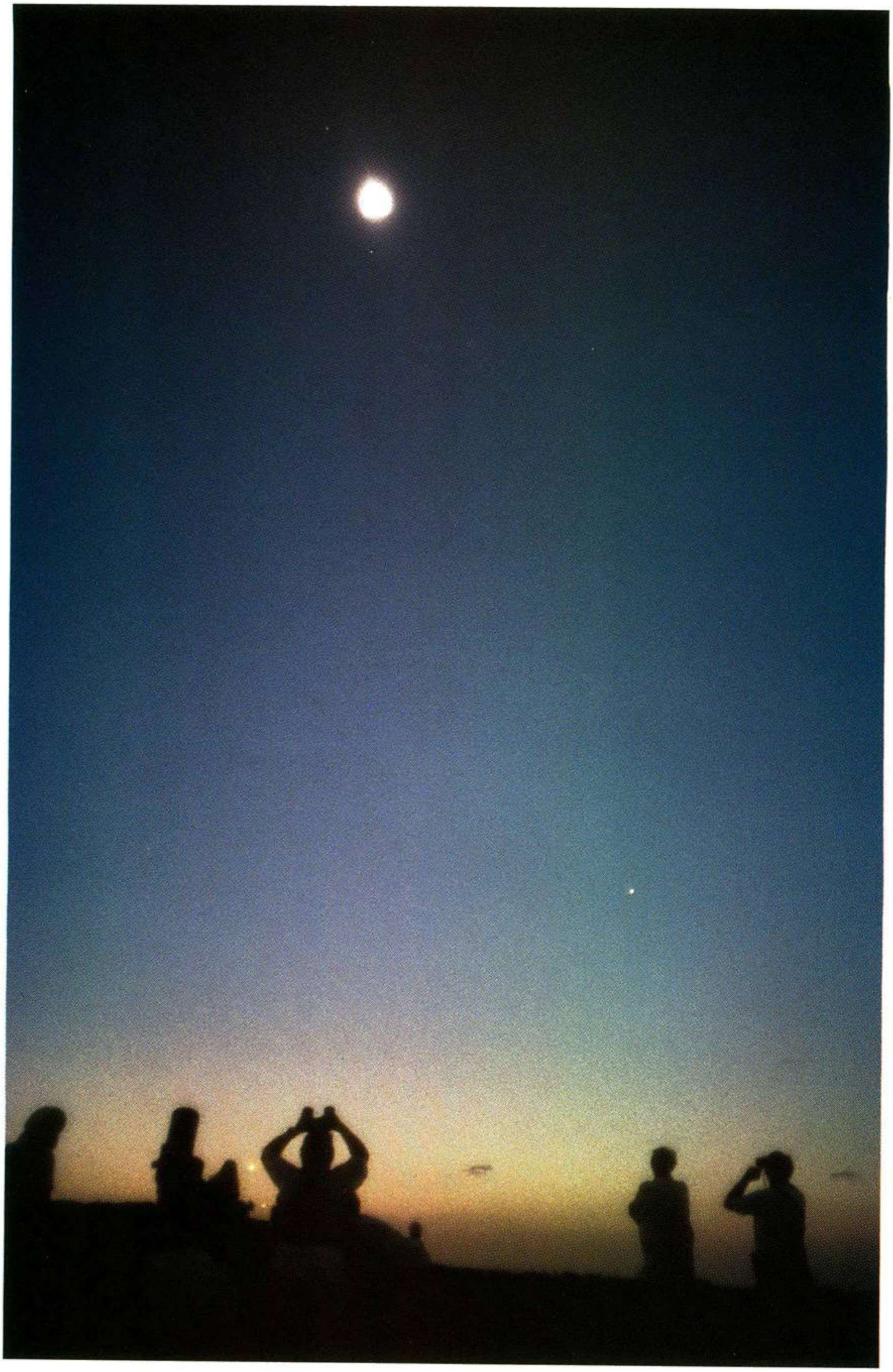


The Great Orion Nebula (M42)

B. Frank Hinson and J. Steve Foster

RUNNER-UP, DIVISION 2: DEEP SPACE

12.5-inch reflector at f/5, Fuji Super HG 800 film, composite of two 30-minute exposures.

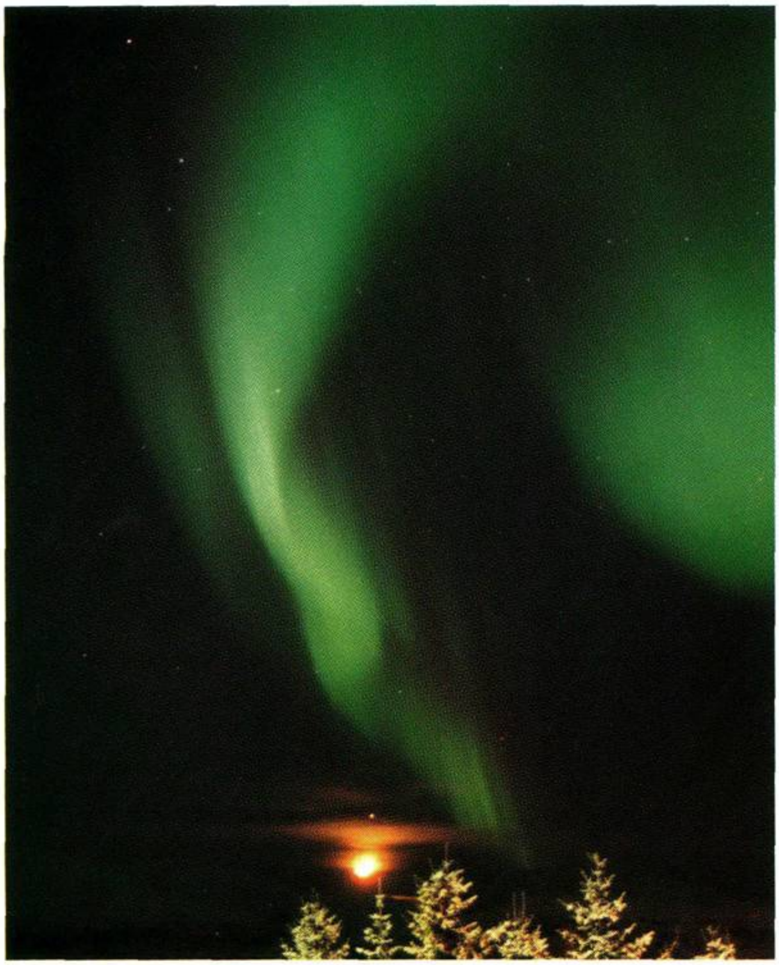


Total Solar Eclipse

Dan Falk

FIRST PLACE, DIVISION 2: UNIQUE EVENTS

24mm lens at f/2.5, Elite 400 film, 1⁄15-second exposure taken February 26, 1998, from Curaçao.



Aurora Dances With the Moon and Saturn

Hinrich Bäsemann

RUNNER-UP, DIVISION 2: UNIQUE EVENTS

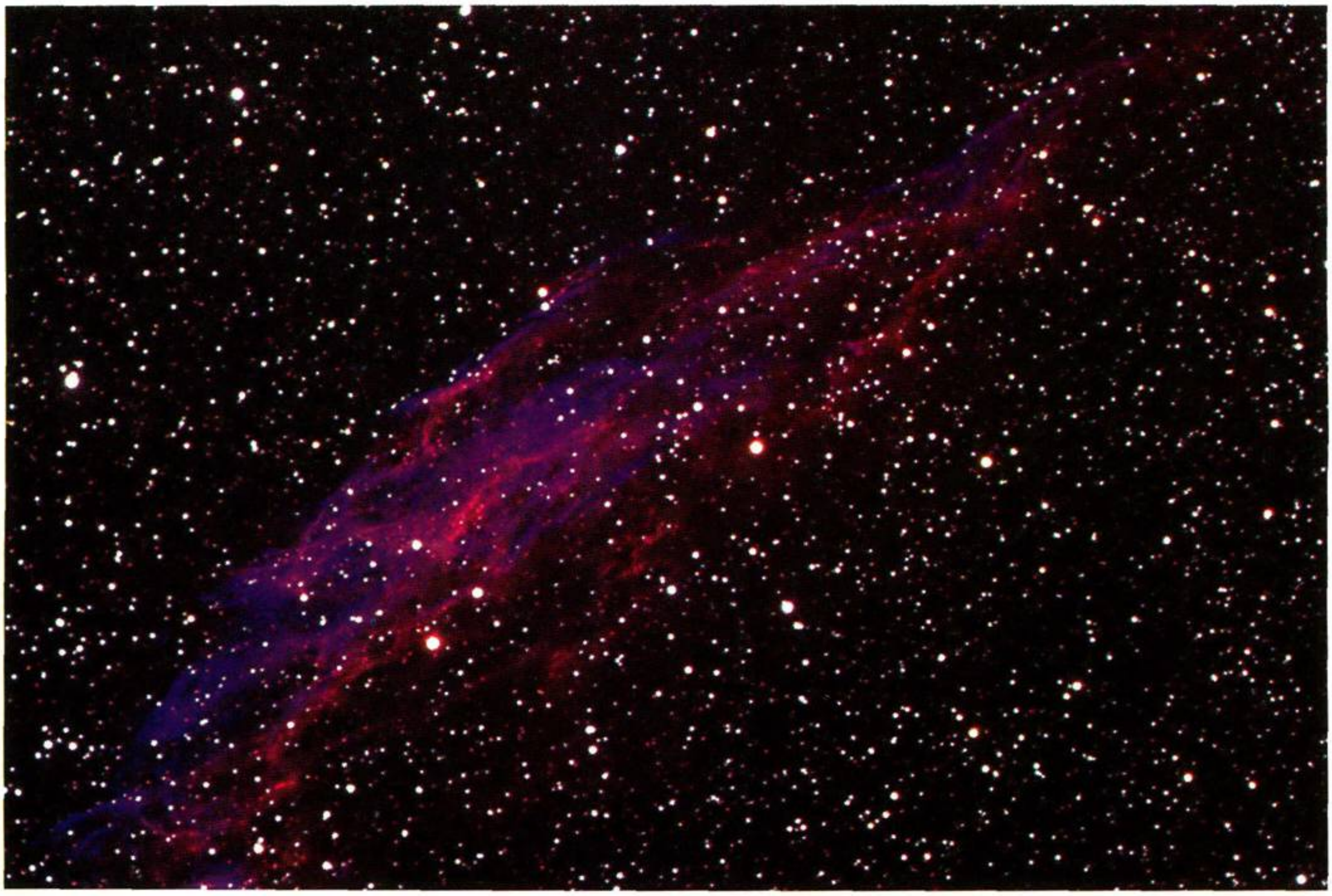
50mm lens at f/1.7, Fujichrome 800 film, 4-second exposure taken February 1, 1998.

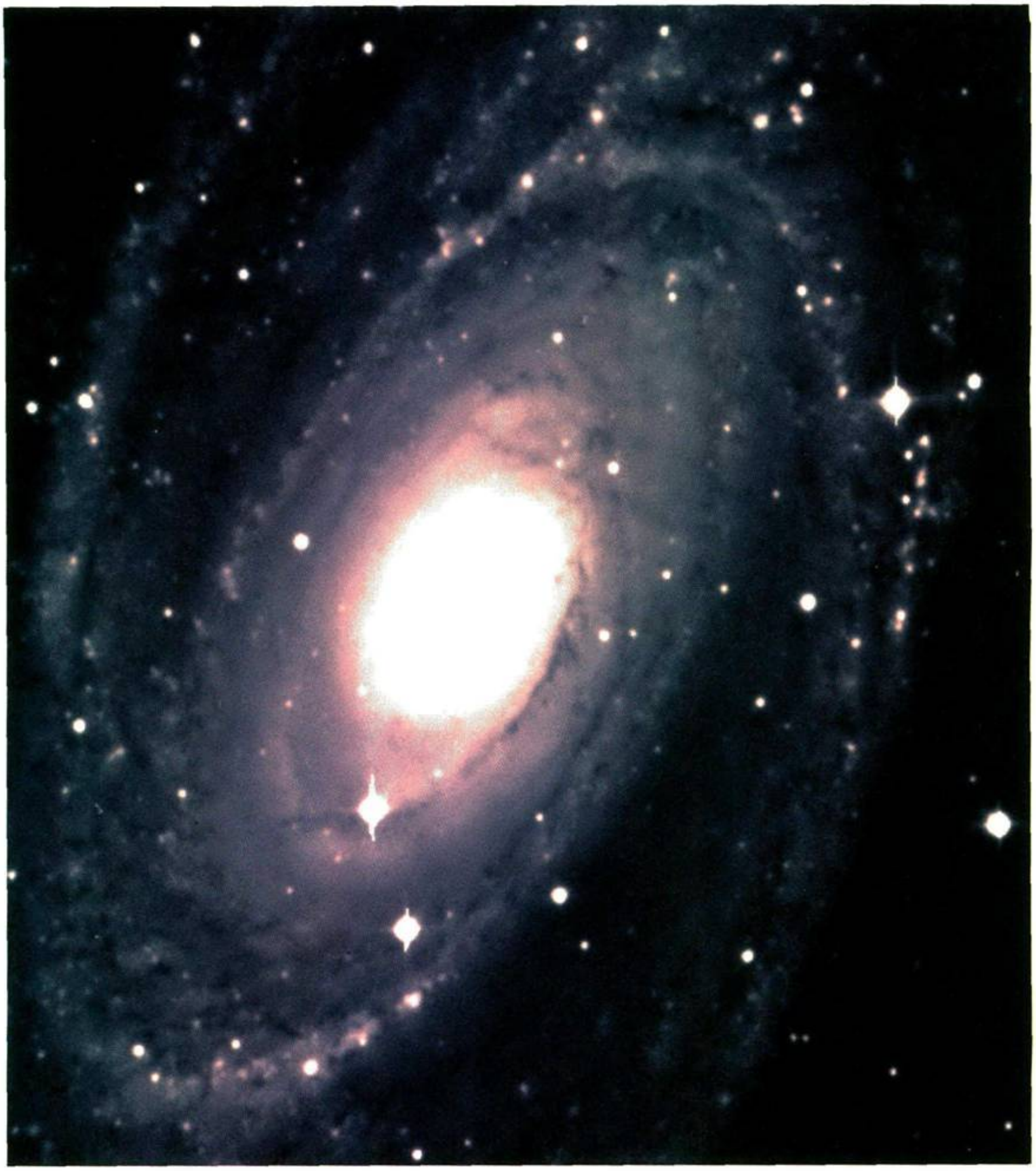
The Veil Nebula (NGC 6992-5)

David Hanon

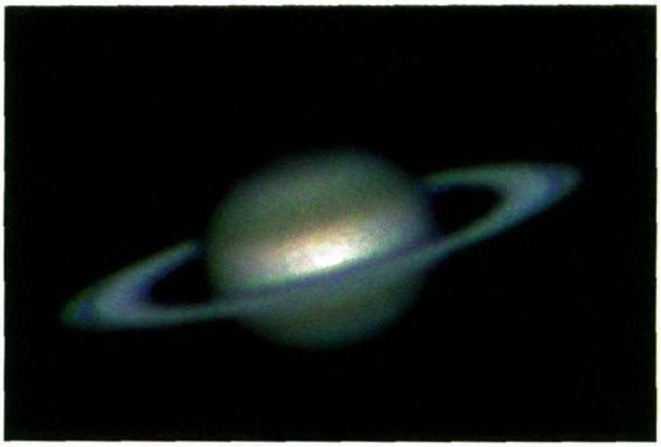
FIRST PLACE, DIVISION 1: DEEP SPACE

7-inch f/9 refractor at f/6, ST-8 CCD camera, composite of 14-minute red, 21-minute green, and 60-minute blue exposures.



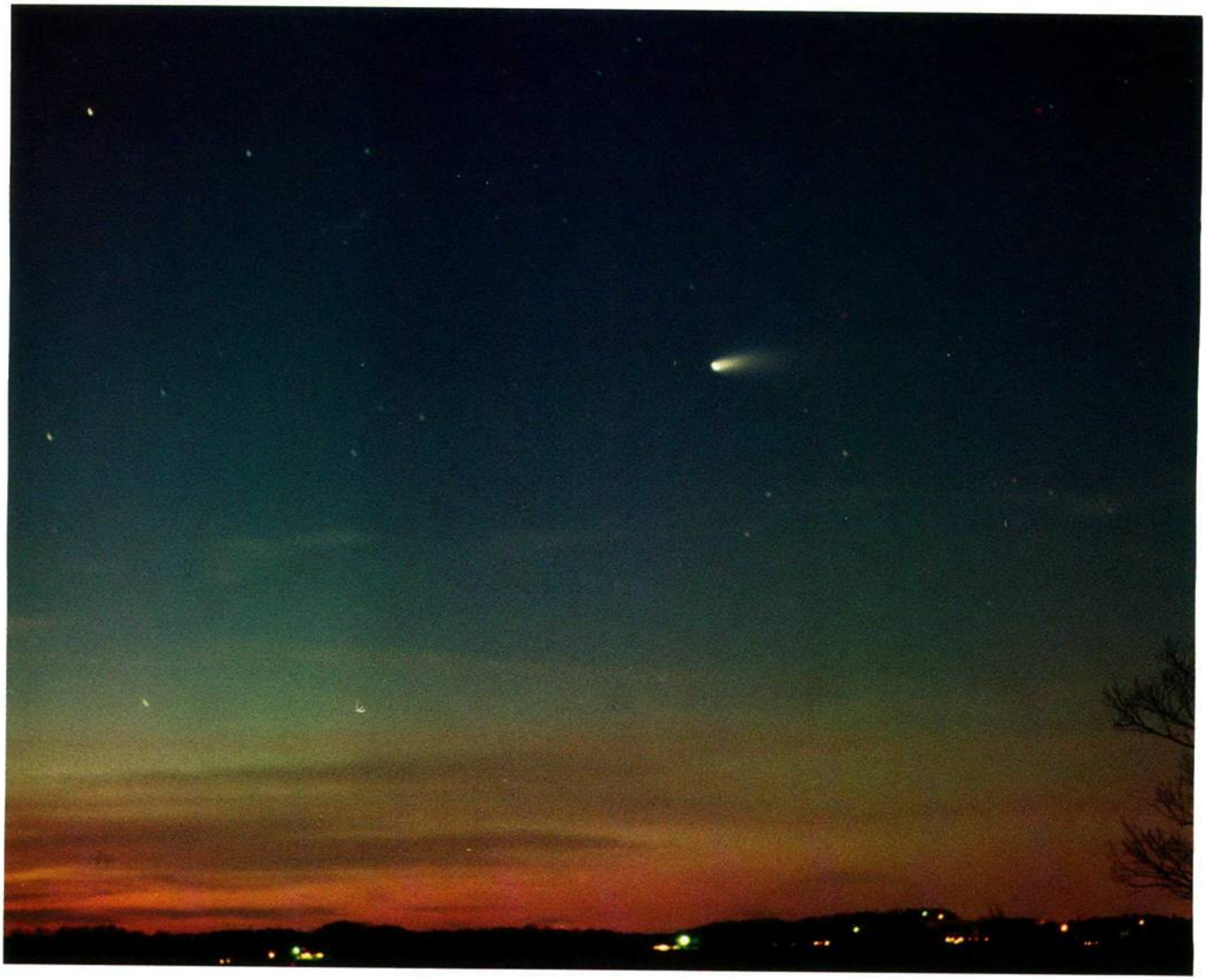


M81 in Ursa Major
Tim Puckett
RUNNER-UP, DIVISION 1: DEEP SPACE
24-inch f/5 Ritchey-Chrétien scope, Apogee AP7 CCD camera, composite of 10-minute red, green, and blue exposures.



Saturn's Rings
David Hanon
RUNNER-UP, DIVISION 1: SOLAR SYSTEM
7-inch refractor at f/50, ST-8 CCD camera, composite of 2-second red, 3-second green, and 8-second blue exposures taken October 6, 1997.

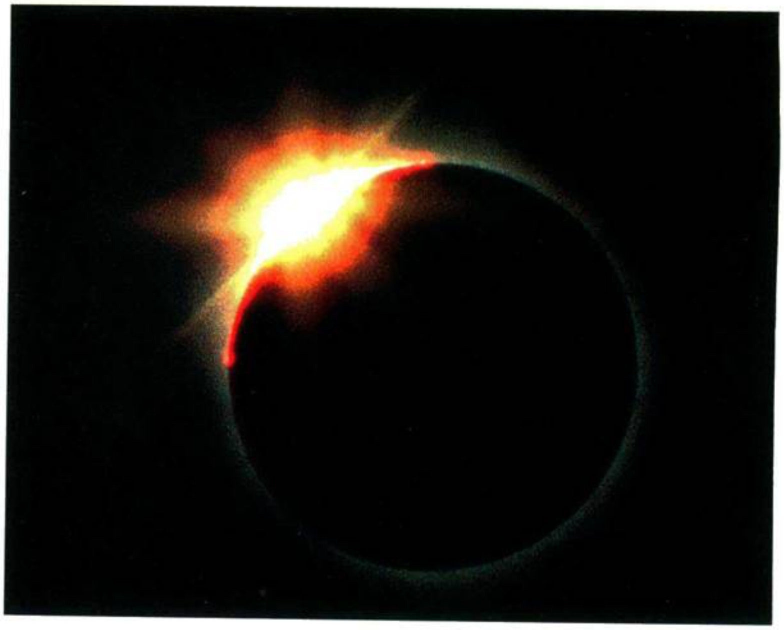
Moon Slice
Michael F. Borman
FIRST PLACE, DIVISION 1: SOLAR SYSTEM
12-inch SCT at f/6.3, ST-7 CCD camera, composite of three 0.1-second exposures taken January 31, 1998.



Comet Hale-Bopp

Jimmy Pruitt

RUNNER UP, (6-11 AGE GROUP)



Diamond Ring

Melanie Kier

FIRST PLACE, (6-11 AGE GROUP)

300mm lens at f/4.5, Kodak 400 slide film, 1/1000-second exposure taken February 26, 1998.

Flame Nebula

Jacob Thumberger

FIRST PLACE (12-16 AGE GROUP)

10-inch f/4.5 reflector, Cookbook 245 CCD camera, composite of four 25-second exposures.

Learjet in Eclipse

Christopher Williams

RUNNER UP, (12-16 AGE GROUP)

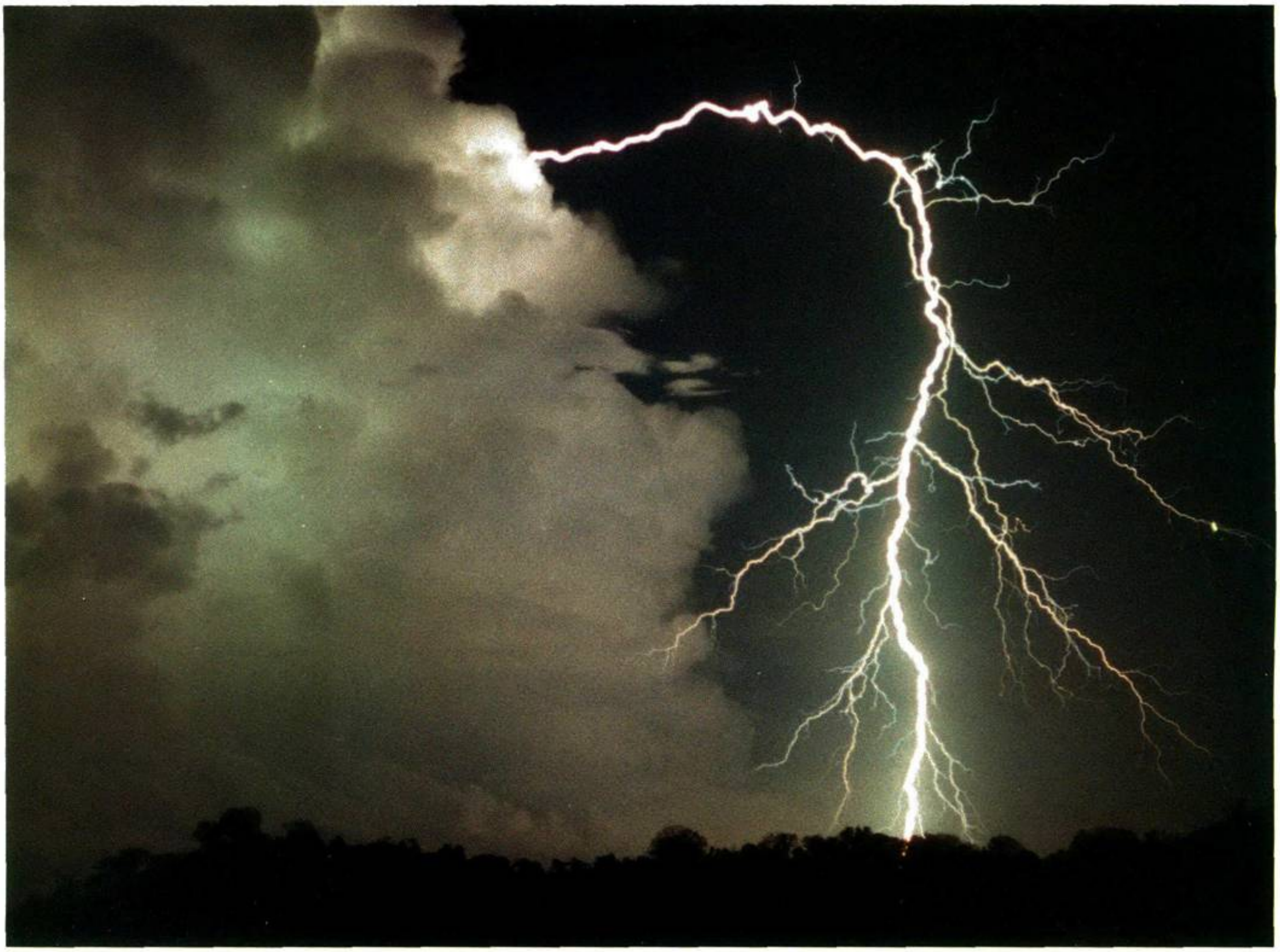
210mm lens at f/22, 400 ISO film, 1/100-second exposure taken February 26, 1998.

Full Moon and Tree Silhouettes

Anthony Olson

RUNNER UP, (12-16 AGE GROUP)

8-inch SCT at f/10, Fuji 400 ISO film, 1/250-second exposure taken July 17, 1997.

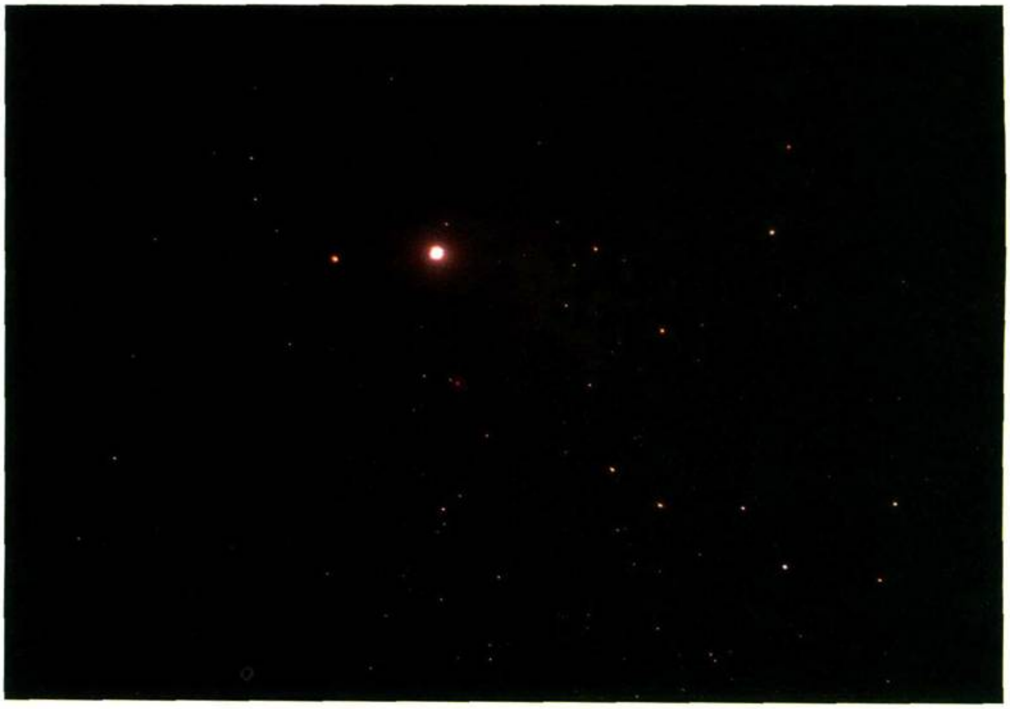


Lightning "Strikes" Jupiter

Frankie Lucena

FIRST PLACE, DIVISION 2: SOLAR SYSTEM

50mm lens at f/4, Kodak Gold Max 800 film, 35-second exposure taken October 4, 1997 in Cabo Rojo, Puerto Rico.



Venus and Mars between Sagittarius and Ophiuchus

Sallie Teames

RUNNER-UP, DIVISION 2: SOLAR SYSTEM

55mm lens at f/1.4, Scotchchrome 400 film, 14-second exposure taken November 2, 1997.

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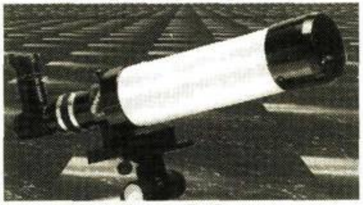

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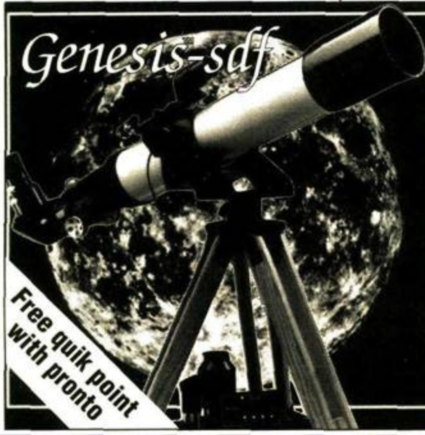

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The Great Nebula in Orion (M42). A composite 60-minute exposure by Jason Ware on Fuji HG400 film with the Meade Model 152ED 6" f/9 *ED* Apochromatic Refractor.

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